Mamm Res (2016) 61:25–33
DOI 10.1007/s13364-015-0250-0

ORIGINAL PAPER

Encounters between medium-sized carnivores and humans in the city of Turku, SW Finland, with special reference to the red fox

Kaarina Kauhala[1] · **Kati Talvitie**[2] · **Timo Vuorisalo**[2]

Received: 3 February 2015 / Accepted: 1 October 2015 / Published online: 21 October 2015
© Mammal Research Institute, Polish Academy of Sciences, Białowieża, Poland 2015

Abstract In recent decades, many carnivore species have colonized urban environments. Human-carnivore interactions have therefore become an important research topic for wildlife managers, conservationists, and urban planners. The aim of the present study was to examine the encounters between medium-sized carnivores and humans in the city of Turku, SW Finland, by collecting data from citizens via internet. The red fox (*Vulpes vulpes*) was the carnivore most often reported as encountered in Turku: foxes were seen about 15 times more often than either raccoon dogs (*Nyctereutes procyonoides*) or badgers (*Meles meles*). Also, litters of all three species were observed suggesting that these carnivores have adapted enough to have breeding populations in the city. We investigated the reported encounters between medium-sized carnivores and humans in different habitats and seasons along the so-called urban-to-rural gradient. All three species were most frequently encountered in gardens. Foxes and raccoon dogs were often encountered on roads, too, whereas badgers were more often encountered in forests. The majority of reported encounters between a medium-sized carnivore and humans occurred in gardens within 5000 m from the city center in the evening and morning in summer and autumn. Foxes were also frequently encountered in open woodland (city parks). Due to the possibility of frequent contacts between wild and domestic carnivores and humans, diseases and parasites might easily spread from one species to another (both wild and domestic) in the urban environment.

Keywords *Meles meles* · Habitat · *Nyctereutes procyonoides* · Urban ecology · *Vulpes vulpes*

Communicated by: Andrzej Zalewski

✉ Kaarina Kauhala
kaarina.kauhala@luke.fi

Timo Vuorisalo
timovuo@utu.fi

[1] Natural Resources Institute Finland, Itäinen Pitkäkatu 3 A, FI-20520 Turku, Finland

[2] Department of Biology, University of Turku, FI-20014 Turku, Finland

Introduction

Many carnivore species have in recent decades colonized urban environments, and human-carnivore interactions have become an increasingly topical research object for wildlife managers, conservationists, and urban planners (Gehrt et al. 2010; and references therein). Urbanization of carnivores may have ecological, economic, psychological, social, as well as health and safety impacts (Hudenko et al. 2010). One of the most thoroughly studied urbanized species is the red fox (*Vulpes vulpes* L.), now probably the most widespread wild carnivore in urban areas of Australia, Europe, Japan, and North America (Harris 1986; Soulsbury et al. 2010). Urban foxes are nowadays well publicized, and for several reasons, including their role as vectors of diseases and parasites, are actively researched in many countries (Macdonald 1987; Deplazes et al. 2003; Soulsbury et al. 2010).

Other carnivores also commonly occur in cities (Gehrt et al. 2010). The raccoon (*Procyon lotor*) is probably the most widespread urban carnivore in North America (Broadfoot et al. 2001; Prange et al. 2003; Hadidian et al. 2010), and it also occurs in some European cities, such as Kassel, Germany (Hohmann et al. 2002). Striped skunks (*Mephitis mephitis*) and coyotes (*Canis latrans*) are also frequently found in urban areas of North America (Gehrt and Riley 2010; Rosatte et al. 2010). Even bobcats (*Lynx rufus*) and mountain lions (*Puma concolor*) roam at the edge of cities (Beier et al. 2010; Riley

et al. 2010). In Europe, urban medium-sized carnivores include, in addition to the fox and raccoon, the stone marten (*Martes foina*) and Eurasian badger (*Meles meles*, L.; Herr et al. 2009; Harris et al. 2010). Badgers live close to the northern limit of their distribution in Finland (Kauhala 2007) and are probably not common in Finnish cities. The invasive raccoon dog (*Nyctereutes procyonoides*, Gray) started to colonize Finland in the 1950s from Russia and had inhabited Southern Finland by the mid1970s (Helle and Kauhala 1991). At present, it is common in NE Europe, and its populations are increasing in Western Europe (Kauhala and Kowalczyk 2011). Although the population density of the raccoon dog is high in Southern Finland (Kauhala 2007), little is known about its occurrence in urban areas.

Where foxes occur in urban areas, their population densities can be high and territories small (Soulsbury et al. 2010; and references therein). Human attitudes toward urban foxes vary (König 2008). High fox densities may lead to conflicts between foxes and people, including the fear of disease or parasite transmission to humans and their pets. Foxes can also attack small companion animals, dig holes in lawns, raid dustbins, and even enter houses to steal food items (Macdonald 1987). On the other hand, many people consider their encounters with urban foxes as positive experiences (König 2008).

The aim of the present study was to examine the encounter frequencies of different medium-sized carnivore species in the city of Turku, SW Finland, and the temporal and spatial distribution of reported encounters. We also monitored observations of carnivore litters and observations of each species' behavior. We partially applied citizen science methodology by collecting data on observed medium-sized wild carnivores in Turku via the internet.

Methods

Study area

The study area was determined as the land area (277 km^2) within 10 km from the center of the city of Turku, SW Finland (Fig. 1). The city center was set to the market place (ETRS-TM35FIN 6711040 N, 239755 E). Turku is a medium-sized town with 182,000 inhabitants. The study area, or urban-to-rural gradient, was divided into four zones: zone 1=<2500 m, zone 2=2500–4999 m, zone 3=5000–7499 m, and zone 4=7500–10,000 m from the city center. The habitat composition of Turku was determined from a digital land cover map (CORINE 2006 Land cover data, ©EEA, produced for Finland by the Finnish Environment Institute SYKE; www.environment.fi). The most common habitat type was "garden", i.e., loosely built areas (Fig. 2). Detailed descriptions of habitat types are given below.

Data collection

We collected data of observed foxes, badgers, and raccoon dogs from the public via internet in 2006–2010. We announced about the questionnaire in the leading local newspaper and other local media. Harris and Rayner (1986) and Scott et al. (2014) found that observations reported by public can generate a large database of fox occurrence and density in urban areas. Accordingly, we asked people to report the location (street address or coordinates), date, and time of day of their observation. We divided the data into four seasons: spring (April–May), summer (June–August), autumn (September–November), and winter (December–March) and to different times of the day: night=midnight to 5:00, morning=5:00 to 12:00, afternoon=12:00 to 17:00, and evening=17:00 to midnight. People also reported about the behavior of the foxes they had observed and encounters of fox litters.

Habitat types

We distinguished ten habitat types: densely built areas, gardens, industrial areas, roads, fields, deciduous, mixed, spruce and pine forests, and open woodlands (Fig. 2).

Densely built areas consisted mainly of apartment buildings and office blocks. Gardens were private gardens and backyards of row houses, detached houses, and villas in residential areas. Roads included all streets, roads, railroads, harbor areas, and an airport. Fields included hayfields and fields of grain, as well as some abandoned fields and pastures. Deciduous forests were forests with >75 % deciduous trees in mineral soil, consisting mainly of birches *Betula pendula* and *B. pubescens*, alders *Alnus* spp., willows *Salix* spp., aspen *Populus tremula*, rowan *Sorbus aucuparia*, oak *Quercus robur*, lime *Tilia cordata*, and European hazel *Corylus avellana*. Mixed forests included forests (in mineral soil) where the proportion of deciduous trees was 25−75 %. Spruce forests were forests with >75 % coniferous trees, mainly *Picea abies*, growing on mineral soil. Pine forests were forests with >75 % coniferous trees, mainly *Pinus sylvestris*, on rocky soil. Also, mixed forests on rocky soil were included in this habitat type. Open woodlands were areas with a canopy coverage of <30 %, and many of them were city parks.

Habitat analyses

We overlaid the coordinates of the reported fox, badger, and raccoon dog encounters on a digital land cover map (CORINE land cover data 2006, resolution 25×25 m). We then determined the habitats of reported carnivore encounters from the map and calculated the frequency distributions of encountered foxes, badgers, and raccoon dogs in different habitats, zones (distance from the city center), seasons, and times of the day. We also created 340 random points and

Fig. 1 Reported encounters between foxes, raccoon dogs, and badgers and humans in different zones (radius 2500, 5000, 7500, and 10,000 m) within 10 km from the city center of Turku. Market place (city center) is shown with a *white asterisk*

tested the difference in the frequency distributions between random points and reported carnivore encounters in different habitats with the χ^2 test.

Because data for badgers and raccoon dogs were scarce, we examined only reported encounters of foxes in more detail and tested the differences in their frequency distributions in different habitats between seasons/zones with the χ^2 test. Furthermore, we tested the difference of the median distance of fox encounters from the city center between the four seasons with the Kruskal–Wallis analysis of variance. We also calculated the density of reported encounters (number/km^2) in each zone.

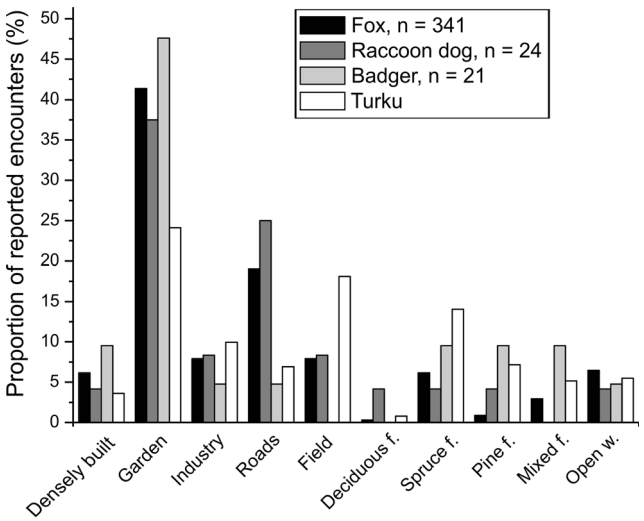

Fig. 2 Proportions of fox, badger, and raccoon dog encounters in different habitats within 10 km from the city center of Turku, SW Finland. The proportions of different habitats in the city of Turku are also shown

Results

Reported encounters of the three carnivore species

The red fox was the carnivore most often reported as encountered in Turku: foxes were encountered in 341 locations, raccoon dogs in 24, and badgers in 21 locations within a 10 km radius from the city center. Most of the reported encounters came from zone 2 (Fig. 1, Table 1). The frequency distributions of reported carnivore encounters in different habitats differed significantly from that of

Table 1 Original numbers of fox, badger, and raccoon dog encounters in different zones in the city of Turku. Densities of carnivore encounters (individuals/km^2) are also given. Zone 1, <2500 m; zone 2, 2500–4999 m; zone 3, 5000–7499 m; and zone 4, 7500–10,000 m from the city center

Species	Zone 1	Zone 2	Zone 3	Zone 4	Total
Red fox	77	200	47	17	341
Raccoon dog	6	13	4	1	24
Badger	4	10	4	3	21
Total	87	223	55	21	386
Area (km^2)	19.6	58.9	98.1	137.4	314.0
Density	4.43	3.79	0.56	0.15	1.23

random points (fox χ^2=80.4, *df*=9, p<0.001; raccoon dog χ^2=18.1, *df*=9, p=0.034; badger χ^2=17.5, *df*=9, p=0.041; Fig. 2). Raccoon dog and badger data were however small. Reported encounters of all three species were biased toward gardens. Fox and raccoon dog encounters were also biased toward roads, whereas badger encounters seemed to be more frequent in forests.

Although most reported encounters of all three species came from zone 2, the highest density of fox encounters occurred in zone 1 (Fig. 3a, Table 1). The few reported badgers were observed relatively more often than other carnivores >5000 m from the city center. All three species were most often encountered in summer and autumn, raccoon dogs and badgers especially in summer (Fig. 3b). Raccoon dogs were rarely encountered in spring and badgers never in winter. Most medium-sized carnivores were encountered either in the morning or in the evening (Fig. 3c). Badgers were observed at night more often than the other two species. Reported fox encounters peaked in the morning hours between 5:00 and 8:00, at noon, at 16:00, and after 18:00 (Fig. 4).

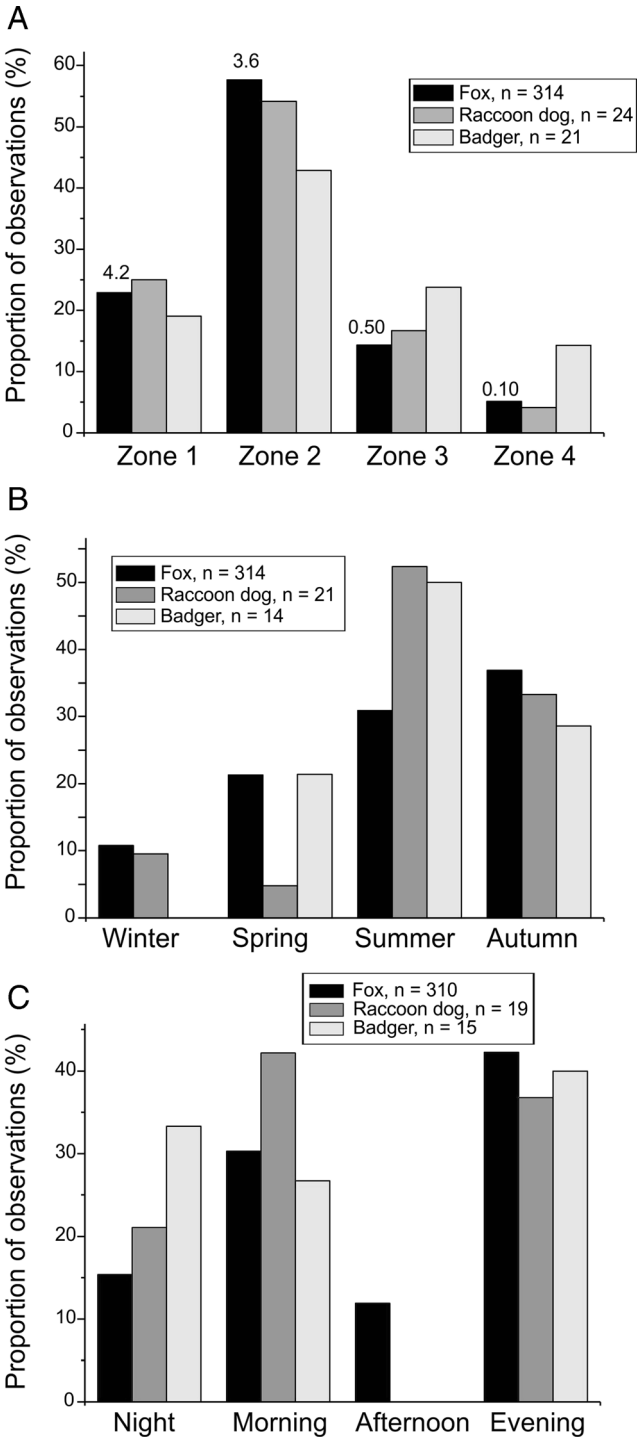

Fig. 3 Proportions of fox, raccoon dog, and badger encounters in different zones (**a**), seasons (**b**), and time of day (**c**) in the city of Turku. Fox observations per square kilometer are given above the columns in **a**

Analyses of reported encounters of foxes

The frequency distributions of fox observations in each habitat differed significantly both between seasons (χ^2=60.3, *df*=36, p=0.007; Fig. 5a) and between zones (χ^2=81.7, *df*=33, p<0.001; Fig. 5b). Most foxes were thus seen in gardens and on roads in summer and autumn in zone 2 and also in gardens in spring. The median distance of fox observations from the city center was lowest in autumn and winter (3.1 km) and largest in summer (4.2 km; K–W test statistic=28.2, p<0.001). Median distance was 3.7 km in spring.

Reports of carnivore litters

One fox litter was observed in zone 1 within 1800 m from the city center. In zone 2, there were ten reported observations of fox litters, representing probably at least five separate litters (Fig. 1). One litter was seen in zone 3, and three observations of litters were made in zone 4, all probably observations of the same litter. Most observations of fox pups were made in

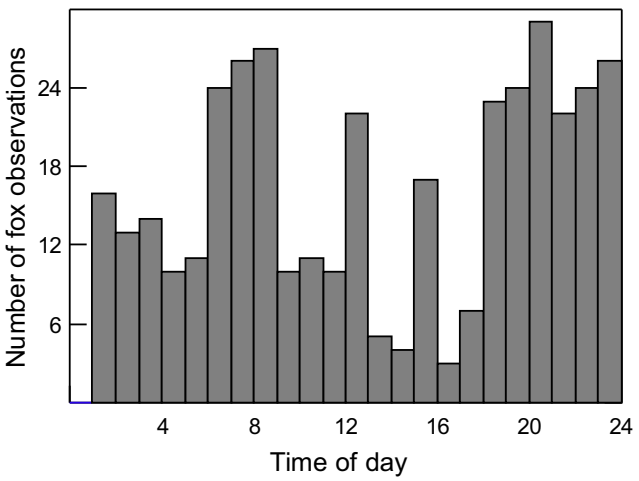

Fig. 4 Numbers of fox encounters in different times of the day in the city of Turku (n=296)

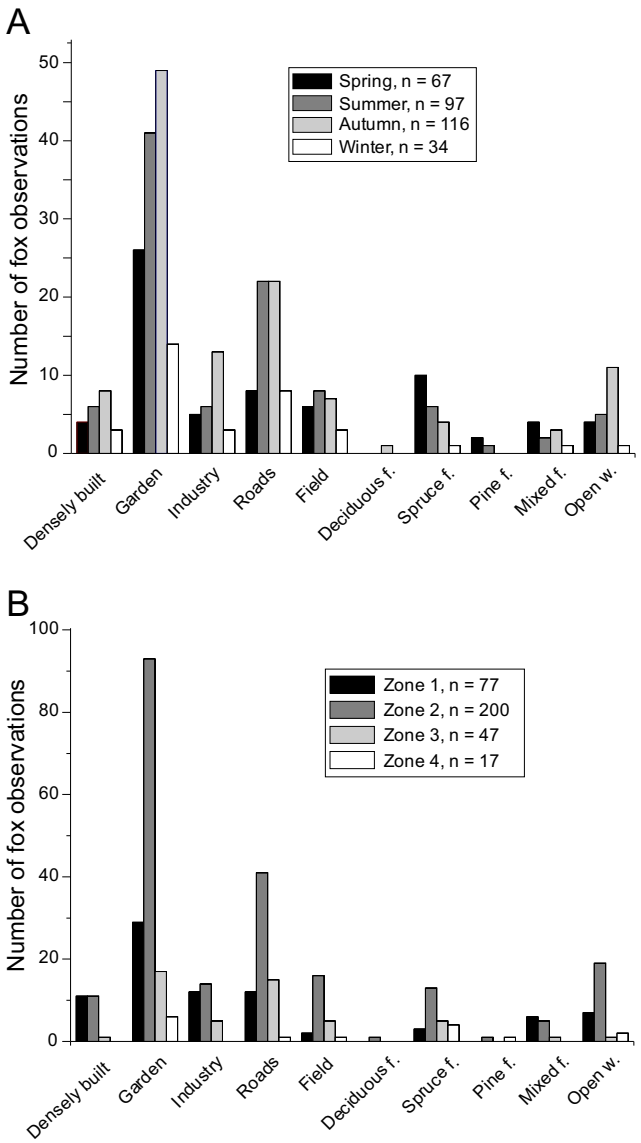

Fig. 5 Numbers of fox encounters in different habitats in different seasons (**a**, $n=314$) and in different zones (**b**, $n=341$) in the city of Turku

gardens, forests, and roads, but one litter was seen in an industrial area and one in a graveyard. Fox dens were found under big rocks in small woods, under buildings, and one in a golf course. The largest number of pups seen was seven in one litter. Besides these observations, there were several reported encounters of "small foxes" which may have been young of the year. One badger litter was observed under a house in zone 2 (3500 m from the city center). One raccoon dog litter was also observed under a building in zone 2 (3500 m) and one in forest in zone 3 (6700 m).

Some observations of behavior of urban carnivores

Foxes were in some occasions observed hunting or carrying prey. Prey animals identified (at least to the class level) were European hares (*Lepus europaeus*, eight cases), rabbits (*Oryctolagus cuniculus*, two cases), squirrels (*Sciurus vulgaris*, two cases), small rodents (three cases), a hooded crow (*Corvus corone cornix*), an unidentified black bird, a few chickens, a cock, and two perches (*Perca fluviatilis*). Foxes were also seen feeding at bird feeders and raiding a dustbin at a hamburger kiosk.

Foxes were observed at a golf course, a school yard, a church yard, a petrol station, a horse stable, in allotment gardens, a bus stop, and even swimming in the sea. Some foxes moved along permanent routes in gardens. Many foxes behaved fearlessly toward people and dogs. In 29 cases, people reported to have been approached by a fox that remained staring at them without running away. In additional 17 cases, people walking with their dogs reported that foxes were not afraid of dogs but seemed instead to be curious and even followed them. However, when people encountered a vixen with pups, the vixen warned the pups which then disappeared back to the den. People also reported foxes which probably suffered from sarcoptic mange (seven cases). They reported that these foxes had a very poor quality of fur or no hair at all in their tail. A three-legged fox in good condition and another limping with a prey animal in its mouth were also observed.

Raccoon dogs were seen in the city center walking along a bridge and along a street by the river Aurajoki. Seven reported observations were from gardens (including an allotment garden) or backyards (one from a yard of a big block of flats in the center) and seven from streets or roads. Two raccoon dogs were found in swimming pools, and one was encountered in the harbor. We received several reports of two or three raccoon dogs seen together.

Most badger observations were from gardens. They were observed to eat nuts offered to squirrels in gardens. Badgers visited gardens at night, and once, a litter was observed in a garden late in a dark evening. Badgers were also seen walking along streets in a densely built area after midnight.

Discussion

Numbers of reported encounters of urban carnivores

The numbers of encounters between carnivores and humans depended on the numbers of carnivores living in the area, the behavior of carnivores (including their habitat preferences and diurnal rhythm), and the density and behavior of people. Furthermore, the numbers of *reported* encounters depended also on the motivation of people to report their observations (Macdonald 1987). Thus, our data are not a random sample of the true number of encounters between carnivores and humans. It is, however, very difficult to assess whether and how our data may be biased. In any case, our data yield valuable information about the encounters between different carnivores and humans, observed carnivore litters, and the

behavior of especially urban foxes. To our knowledge, this is the first study of the subject in Finland.

Most reports of encountered carnivores concerned foxes: the number of observed foxes was about 15 times higher than the numbers observed for raccoon dogs and badgers. Urbanization of the red fox started more than 100 years ago in Finland (Vuorisalo et al. 2014), and foxes are known to be common in urban areas also in other countries, such as Britain, Switzerland, Estonia, and Germany (e.g., Gloor et al. 2001; Harris and Baker 2001; Soulsbury et al. 2010; Janko et al. 2012; Plumer et al. 2014). Badger densities are much lower in Finland (Kauhala 2007), and one would therefore not expect to observe dense badger populations in Finnish cities. Although raccoon dogs are common in Finland, existing data of their occurrence in cities are scarce. The large number of reported fox encounters in relation to those of the raccoon dogs and badgers therefore probably reflects genuinely their larger numbers in Turku.

Foxes may be common in urban areas due to abundant food sources (e.g., Contesse et al. 2004; Plumer et al. 2014). Although mammals, especially rodents and lagomorphs, as well as birds are the main prey items of foxes in the Finnish countryside (Kauhala et al. 1998a), the fox is an omnivore and can live on almost any food source (e.g., Macdonald 1987; Doncaster et al. 1990; Harris and Baker 2001). In the present study, foxes were seen to prey on both mammals and birds and to utilize anthropogenic food sources. An observation of a three-legged fox apparently in a good condition suggests that even permanently disabled foxes can do well in the city where food is easily available. Scavenged food was common in fox diet also in Bristol and in Zürich (Harris and Baker 2001, Contesse et al. 2004; Deplazes et al. 2003). Also, raccoon dogs and badgers are omnivores (Kauhala et al. 1998b) and may have urbanized to some extent due to abundant food resources available in the city.

Activity times (diurnal rhythm) and behavior of both carnivores and humans also affect the number of reported encounters. Many foxes did not seem to be afraid of people or their dogs. This fact evidently affects the high numbers of foxes observed and reported by people. Foxes show habituation to human presence, probably because many people like urban foxes, and some even actively feed them (Plumer et al. 2014, Hegglin et al. 2015). Badgers are active mainly late in the evening or at night and avoid being disturbed by people (Kowalczyk et al. 2003; Harris et al. 2010) and are therefore more rarely observed. The few badger encounters in the present study indeed took place during the dark hours. Although foxes and raccoon dogs move mainly during dusk and dawn, they are sometimes active at daytime, particularly in spring and summer when they have pups to feed (Kauhala et al. 1998b; Harris and Baker 2001; Kauhala et al. 2007) and are thus more often encountered by people. No badgers were seen in winter because they hibernate during the coldest season. Also, raccoon dogs hibernate but may still be active in winter during mild weather (Kauhala et al. 2007). Foxes, too, are less active in winter than in summer, except in the mating season (Harris and Baker 2001). Also, people move less often outside in winter which affects the low numbers of encounters with carnivores.

Distribution of carnivore observations in different habitats

Habitat preferences of carnivores and the time people spend in these habitats also affect the number of reported encounters. In Turku, the majority of reported encounters between carnivores and humans occurred in gardens of residential areas in zone 2 where row and detached houses are common. People spend a lot of time at home and in their gardens, especially in summer and autumn when most carnivores were encountered there. It can also not be ruled out that people may more willingly report encounters of carnivores in their own gardens in comparison to encounters in other areas. Animals visit gardens in search of food: they dig in compost heaps, and consume leftovers after a barbeque dinner, food offered for dogs, cats, birds, or hedgehogs (*Erinaceus europaeus*), as well as berries and fruit. Harris and Rayner (1986) and Macdonald (1987) also reported that foxes favored residential areas, especially gardens of detached houses. In the island of Ruissalo (west from Turku center, zones 2–4), radio-tracked raccoon dogs also favored gardens (Kauhala and Auttila 2010). Gardens also offer shelter to animals: fox earths are sometimes located under garden sheds (Macdonald 1987; Harris et al. 2010).

Foxes and raccoon dogs were also frequently encountered on roads. Naturally, people also use roads frequently and thus encounter animals there more often than in forests. Badgers are more secretive than urban foxes and avoid open habitats, such as roads (Davidson et al. 2008; Harris et al. 2010), or prefer to use roads at night (indeed, they were seen in streets in the densely built area after midnight) and are therefore less often encountered by people. In Turku, badgers were observed more often than other carnivores in forests. The badger data were, however, very small. Also in Britain and Denmark, badgers are known to use gardens close to woodland or woodlands in suburban areas (Aaris-Sørensen 1987; Harris et al. 2010). In the island of Ruissalo, badgers also preferred forest, and their setts were in this habitat (Kauhala and Auttila 2010).

We investigated the reported fox observations in more detail in different seasons and along the so-called urban-to-rural gradient where conditions and exposure to urban disturbance change more or less predictably with distance from the urban core (McDonnell and Pickett 1990; Alberti et al. 2001; McKinney 2002). Foxes were encountered in all habitats in Turku indicating their great adaptability: they are very flexible in their habitat and food requirements (e.g., Harris and Baker 2001). Besides gardens and roads, foxes were frequently

encountered in open woodland, i.e., city parks and church yards. They were seen in graveyards also in Oxford (Macdonald 1987), suggesting that they favor green areas in the city. A fox litter was indeed seen near a graveyard close to the Resurrection Chapel of Turku.

Several observations of fox litters in Turku indicated that urbanization of the fox in the area is in phase three as defined by Evans et al. (2010): there is already a local breeding population. Although one fox litter was observed in zone 1, most observations of fox litters were from zone 2, indicating that foxes usually choose a den site outside the densely built areas in Turku. Two raccoon dog litters and one badger litter were also observed, suggesting that even raccoon dogs and badgers have breeding populations in or very near Turku.

Foxes were encountered in forests especially in spring. The breeding den may be in the forest, e.g., in an old badger sett, although it can also be under buildings, even in occupied houses under floorboards (once observed in the present study), or in gardens and other places in the city (Harris and Baker 2001; Harris et al. 2010; Janko et al. 2012). Foxes were sometimes observed on fields in zone 2, maybe because they are easier to detect in an open field. Foxes catch small rodents on fields even in daylight, especially when they have cubs to feed (K. Kauhala, personal observation).

Foxes were encountered most often at times when people move outside, in early morning hours when people go to work (and many of them walk their dogs before that), at lunch time, in late afternoon when people return home, and in the evening when both foxes and people are on the move. Foxes were rarely encountered in winter, and the median distance of fox observations from the city center was low suggesting that both people and foxes move in the city center in winter.

Medium-sized carnivores as vectors of diseases and parasites

The frequent visits of foxes and raccoon dogs in gardens increase the risk of disease and parasite transmission to domestic animals and humans. Although Finland is a rabies-free country, rabies still exists in foxes and raccoon dogs in our eastern neighbour, the Russian Federation (Freuling and Müller 2013 a, b). Furthermore, people illegally import unvaccinated pets from countries where rabies exists. The pooled density of potential vector species (foxes and raccoon dogs) in Turku would likely be higher than the threshold density needed for rabies epizootics (Singer et al. 2009).

Urban carnivores may also transmit other diseases and parasites, such as the itch mite *Sarcoptes scabiei* which causes sarcoptic mange (Kołodziej-Sobocińska et al. 2014), and *Echinococcus multilocularis* which causes human alveolar echinococcosis (Rausch et al. 1987). Some foxes apparently suffering from sarcoptic mange were reported during our study in Turku. Mange has been observed in city foxes also in Bristol where it caused a crash in the urban fox population and in Estonia where 8 % of urban foxes had symptoms of the mange (Baker et al. 2000; Harris and Baker 2001; Plumer et al. 2014). The infection may spread in direct contact between animals or at commonly used den sites both within and between species (Balestrieri et al. 2006; Kołodziej-Sobocińska et al. 2014). Also, dogs can get sarcoptic mange (Scheidt et al. 1984).

Echinococcus multilocularis requires a rodent as an intermediate host, and foxes, raccoon dogs, and domestic dogs may be infected when they eat rodents (e.g., Deplazes et al. 2003; Romig et al. 2006; Schwarz et al. 2011). Eggs of the parasite spread from feces of definitive hosts and can also infect people. In Zürich, for instance, up to 47 % of foxes were infected (Hofer et al. 2000; Deplazes et al. 2003). The parasite is spreading toward north in Europe and if it reaches Finland, it could spread in the dense canid populations of Finnish towns, such as Turku.

Conclusions

Foxes, raccoon dogs, and badgers have adapted to urban life in SW Finland. Even litters of all three species were observed suggesting that they have breeding populations within the city. The red fox is the carnivore most often encountered probably because it is the most common medium-sized carnivore in the area and is not very secretive in its behavior. All three species are most often encountered in gardens, and foxes and raccoon dogs also on roads. The possibility of frequent interactions between medium-sized carnivores, humans, and their pets may pose a risk for epizootics: diseases and parasites may easily spread from one species to another and also to humans. More research is needed of the true densities of medium-sized carnivores in Finnish cities to be able to plan measures to mitigate the risk of disease spread by them.

Acknowledgments We wish to thank all citizens who responded to our questionnaire of carnivore observations in Turku. We are most grateful to John Loehr who corrected the English language of the manuscript.

References

Aaris-Sørensen J (1987) Past and present distribution of badgers *Meles meles* in the Copenhagen area. Biol Cons 41:159–165

Alberti M, Botsford E, Cohen A (2001) Quantifying the urban gradient: linking urban planning and ecology. In: Donnelly R, Marzluff JM, Bowman R (eds) Avian ecology and conservation in an urbanizing world. Kluwer Academic Publishers, Boston, pp 89–115

Baker PJ, Funk SM, Harris S, White PCL (2000) Flexible spatial organization of urban foxes, *Vulpes vulpes*, before and during an outbreak of sarcoptic mange. Anim Behav 59:127–146

Balestrieri A, Remonti L, Ferrari N, Ferrari A, Valvo TL, Robetto S, Orusa R (2006) Sarcoptic mange in wild carnivores and its co-

occurrence with parasitic helminthes in the Western Italian Alps. Eur J Wildl Res 52:196–201
Beier P, Riley SPD, Sauvajot RM (2010) Mountain lions (*Puma concolor*). In: Gehrt SD, Seth SPD, Cypher BL (eds) Urban carnivores. Ecology, conflict, and conservation. Johns Hopkings University Press, Baltimore, pp 141–155
Broadfoot JD, Rosatte RC, O'Leary DT (2001) Raccoon and skunk population models for urban disease control planning in Ontario, Canada. Ecol Appl 11:295–303
Contesse P, Hegglin D, Gloor S, Bontadina F, Deplazes P (2004) The diet of urban foxes (*Vulpes vulpes*) and the availability of anthropogenic food in the city of Zurich, Switzerland. Mamm Biol 69:81–95
Davidson J, Huck M, Delahay RJ, Roper TJ (2008) Restricted ranging behaviour in a high-density population of urban badgers. J Zool 277: 45–53
Deplazes P, Hegglin D, Gloor S, Romig T (2003) Wilderness in the city: the urbanization of *Echinococcus mutilocularis*. Trends Parasitol 20: 77–84
Doncaster CP, Dickman CR, Macdonald DW (1990) Feeding ecology of red foxes (*Vulpes vulpes*) in the city of Oxford, England. J Mammal 71:188–194
Evans KL, Hatchwell BJ, Parnell M, Gaston KJ (2010) A conceptual framework for the colonization of urban areas: the blackbird *Turdus merula* as a case study. Biol Rev 85:643–667
Freuling C, Müller T (2013a) Rabies Bulletin Europe 37(1):1–26
Freuling C, Müller T (2013b) Rabies Bulletin Europe 37(2):1–24
Gehrt SD, Riley SPD (2010) Coyotes (*Canis latrans*). In: Gehrt SD, Seth SPD, Cypher BL (eds) Urban carnivores. Ecology, conflict, and conservation. Johns Hopkings University Press, Baltimore, pp 79–95
Gehrt SD, Riley SPD, Cypher BL (eds) (2010) Urban carnivores. Ecology, conflict, and conservation. The Johns Hopkins University Press, Baltimore
Gloor S, Bontadina F, Hegglin D, Deplazes P (2001) The rise of urban fox populations in Switzerland. Mamm Biol 66:155–164
Hadidian J, Prange S, Rosatte R, Riley SPD, Gehrt SD (2010) Raccoons (*Procyon lotor*). In: Gehrt SD, Seth SPD, Cypher BL (eds) Urban carnivores. Ecology, conflict, and conservation. Johns Hopkings University Press, Baltimore, pp 35–47
Harris S (1986) Urban foxes. Whitted Books, London
Harris S, Baker P (2001) Urban foxes. Whitted Books, Suffolk, UK
Harris S, Rayner JMV (1986) Urban fox (*Vulpes vulpes*) population estimates and habitat requirements in several British cities. J Anim Ecol 55:575–591
Harris S, Baker PJ, Soulsbury CD, Iossa G (2010) Eurasian Badgers. In: Gehrt SD, Seth SPD, Cypher BL (eds) Urban carnivores. Ecology, conflict, and conservation. Johns Hopkings University Press, Baltimore, pp 109–119
Hegglin D, Bontadina F, Deplazes P (2015) Human-wildlife interactions and zoonotic transmission of *Echinococcus multilocularis*. Trends in Parasitology 31:167–173
Helle E, Kauhala K (1991) Distribution history and present status of the raccoon dog in Finland. Holarct Ecol 14:278–286
Herr J, Schley L, Roper TJ (2009) Socio-spatial organization of urban stone martens. J Zool 277:54–62
Hofer S, Gloor S, Müller U, Mathis A, Hegglin D, Deplazes P (2000) High prevalence of *Echinococcus multilocularis* in urban red foxes (*Vulpes vulpes*) and voles (*Arvicola terrestris*) in the city of Zürich, Switzerland. Parasitology 120:135–142
Hohmann U, Voigt S, Andreas U (2002) Raccoons take the offensive: a current assessment. Neobiota 1:191–192
Hudenko HW, Siemer WF, Decker DJ (2010) Urban carnivore conservation and management. In: Gehrt SD, Riley SPD, Cypher BL (eds) Urban carnivores. Ecology, conflict and conservation. Johns Hopkins University Press, Baltimore, pp 21–33
Janko C, Schröder W, Linke S, König A (2012) Space use and resting site selection of red foxes (*Vulpes vulpes*) living near villages and small towns in Southern Germany. Acta Theriol 57:245–250
Kauhala K (2007) Paljonko Suomessa on pienpetoja [Numbers of medium-sized carnivores in Finland]. Riista- ja kalatalous− Selvityksiä 1/2007: 1–18
Kauhala K, Auttila M (2010) Habitat preferences of the native badger and the invasive raccoon dog in southern Finland. Acta Theriol 55:231–240
Kauhala K, Kowalczyk R (2011) Invasion of the raccoon dog *Nyctereutes procyonoides* in Europe: history of colonization, features behind its success, and threats to native fauna. Curr Zool 55:584–598
Kauhala H, Helle E, Pietilä H (1998a) Time allocation of male and female raccoon dogs to pup rearing at the den. Acta Theriol 43: 301–310
Kauhala K, Laukkanen P, von Rege I (1998b) Summer food composition and food niche overlap of the raccoon dog, red fox and badger in Finland. Ecography 21:457–463
Kauhala K, Holmala K, Schregel J (2007) Seasonal activity patterns and movements of the raccoon dog, a vector of diseases and parasites, in southern Finland. Mamm Biol 72:342–353
Kołodziej-Sobocińska M, Zalewski A, Kowalczyk R (2014) Sarcoptic mange vulnerability in carnivores of the Białowieża Primeval Forest, Poland: underlying determinant factors. Ecol Res 29:237–244
König A (2008) Fears, attitudes and opinions of suburban residents with regards to their urban foxes. Eur J Wildl Res 54: 101–109
Kowalczyk R, Jędrzejewska B, Zalewski A (2003) Annual and circadian activity patterns of badgers (*Meles meles*) in Białowieża Primeval Forest (eastern Poland) compared with other Palaearctic populations. J Biogeography 30:463–472
Macdonald D (1987) Running with the fox. Unwin Hyman, London
McDonnell MJ, Pickett STA (1990) Ecosystem structure and function along urban–rural gradients: an unexploited opportunity for ecology. Ecology 71:1232–1237
McKinney ML (2002) Urbanization, biodiversity, and conservation. Bioscience 52:883–890
Plumer L, Davison J, Saarma U (2014) Rapid urbanization of red foxes in Estonia: distribution, behaviour, attacks on domestic animals, and health-risks related to zoonotic diseases. PLOS ONE. doi:10.1371/journal.pone.0115124.
Prange S, Gehrt SD, Wiggers EP (2003) Demographic factors contributing to high raccoon densities in urban landscapes. J Wildl Manage 67:324–333
Rausch RL, Wilson JF, Schantz PM, McMahon BJ (1987) Spontaneous death of Echonococcus multilocularis: Cases diagnosed serologically (by Ems ELISA) and clinical significance. Trop Med Hyg 36: 576–585
Riley SPD, Boydston EE, Crooks KR, Lyren LM (2010) Bobcats (*Lynx rufus*). In: Gehrt SD, Seth SPD, Cypher BL (eds) Urban carnivores. Ecology, conflict, and conservation. Johns Hopkings University Press, Baltimore, pp 121–138
Romig T, Dinkel A, Mackenstedt U (2006) The present situation of echinococcosis in Europe. Parasitol Int 55:S187–S191
Rosatte R, Sobey K, Dragoo JW, Gehrt SD (2010) Striped skunks and allies (*Mephitis spp.*). In: Gehrt SD, Seth SPD, Cypher BL (eds) Urban carnivores. Ecology, conflict, and conservation. Johns Hopkings University Press, Baltimore, pp 97–106
Scheidt VJ, Medleau L, Seward RL, Schwartzman RM (1984) An evaluation of ivermectin in the treatment of sarcoptic mange in dogs. Am J Vet Res 45:1201–1202

Schwarz S, Sutor A, Staubach C, Mattis R, Tackmann K, Conraths FJ (2011) Estimated prevalence of *Echinococcus multilocularis* in raccoon dogs *Nyctereutes procyonoides* in northern Brandenburg, Germany. Curr Zool 57:655–661

Scott DM, Berg MJ, Tolhurst BA, Chauvenet ALM, Smith GC, Neaves K, Lochhead J, Baker PJ (2014) Changes in the distribution of red foxes (*Vulpes vulpes*) in urban areas in Great Britain: findings and limitations of a media-driven nationwide survey. PLoS ONE 9(6):e99059. doi:10.1371/journal.pone.0099059

Singer A, Kauhala K, Holmala K, Smith GC (2009) Rabies in Northeastern Europe—the threat from invasive raccoon dogs. J Wildl Dis 45:1121–1137

Soulsbury CD, Baker PJ, Iossa G, Harris S (2010) Red foxes (*Vulpes vulpes*). In: Gehrt SD, Riley SPD, Cypher BL (eds) Urban carnivores. Ecology, conflict and conservation. Johns Hopkins University Press, Baltimore, pp 63–75

Vuorisalo T, Talvitie K, Kauhala K, Bläuer A, Lahtinen R (2014) Urban red foxes (*Vulpes vulpes* L.) in Finland: a historical perspective. Landsc Urban Plan 124:109–117