Short communication

Seasonal and sex-specific differences in feeding site attendance by red foxes *Vulpes vulpes*

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Abstract

Food provided by householders represents a key resource for urban red foxes *Vulpes vulpes*. Using long-term video footage, we examined how patterns of feeding site attendance varied with season, sex and likely residence status. For foxes attending frequently (>15%) we found feeding site attendance highest for females in spring, probably because of feeding dependent young, and lowest for both sexes in autumn because of changes in seasonal food abundance or in time spent in other activities. For infrequent attenders (<15%), females attended most often in autumn and winter, coinciding with the dispersal period. Male attendance was not higher during the breeding season. Our combined results show how feeding site attendance changes throughout the year relative to potential intrinsic and extrinsic factors.

Key words: resources, scavenged food, carnivores, urban, dispersal, anthropogenic

Introduction

Urban red foxes are globally widespread, being found on all continents where red foxes occur (Soulsbury et al. 2010). In most countries, urban fox diet is largely composed of deliberately provisioned food items such as household waste (summarised in Soulsbury et al. 2010), so that feeding sites provided by householders are a key resource. Such food is substantial; in urban Bristol UK, for example, approximately 10% of households (14-49 houses per territory) provided food specifically for foxes (Baker et al. 2000, 2004). Though urban foxes utilise these feeding sites extensively, they also feed on a range of natural food items. Food not deliberately provided comprised 65% in London (Harris 1981) and 48% of diet in Zurich (Contesse et al. 2004). So reliance on feeding site could vary seasonally depending on natural food availability (Tsukada & Nonaka 1996) or on intrinsic factors. For example, attendance may be highest during spring/summer when parents or other group members are food provisioning cubs (Soulsbury et al. 2008). In contrast, infrequent attenders at feeding sites would be expected most often during autumn and winter, coincident with dispersal and reproductive movements (Baker et al. 2001; Soulsbury et al. 2011). Alternatively, feeding sites could be used year-round, representing a stable source of food.

Feeding sites may be important not only for resident territory holders. Sites that provide super-abundant food may also attract foxes from neighbouring territories or further away (e.g. Tsukada 1997) and movements between neighbouring territories can occur year-round (Baker et al. 2001). Despite all the relevant variables, information is lacking about seasonal variation in feeding site attendance by both resident and trespassing foxes of each sex. Changes in usage by different categories of individuals may mask patterns of attendance but little has been reported about how individuals of different categories react to and utilise a stable resource. So, in this study, we used a long-term series of video footages in a residential UK garden to test how individual patterns of attendance varied with season and sex, and

between resident and trespassing foxes. Long-term monitoring permits individual identification and previous work has examined patterns of urine marking in adults and cubs (Fawcett et al. 2013; Soulsbury & Fawcett 2015). Here we report patterns of individual feeding site attendance and how these varied with sex, season and whether the individuals were seen relatively frequently and likely to be residents, or less frequently and likely to be non-residents.

Methods

Study site and video setup

The study was conducted within a largish garden in the New Forest, Hampshire during 2007-2012. The surrounding habitat was fairly widely-spaced detached housing adjacent to open heathland. Foxes frequently attended a feeding site about 15m x 20m wide, mainly rough lawn backed by shrubs. Food, mostly left over from domestic use, was placed each evening on a patio. Foxes generally arrived through a gap under a fence, though other routes were sometimes used (see Fawcett et al. 2013 for diagram of setup).

Two infra-red/colour video cameras, with microphones and with focal length set to about 35mm, recorded the area from approximately one hour before sunset throughout each night. Cameras were located near the food, so as to maximise detail when foxes were present, but depth of field allowed observation of distant activity. Six infra-red lamps provided even illumination. There was continuous recording from the cameras to two DVD-recorders and the results were monitored each following morning.

Data collection

Individual foxes usually have a distinctive combination of morphological features such as white tag, ear and facial scarring, ear spots, or black colouration. Through this method regular attenders are easily identifiable, though those visiting infrequently could be mis-identified as new. We restricted our data to full grown individuals (>6 months: Soulsbury et al. 2008). This category includes juveniles who potentially may be dispersing (Soulsbury et al. 2011).

We defined attendance (yes/no) of each individual each night depending on whether it was observed at any time during that night. It was clear that attendance of individuals fitted a bimodal distribution with low attendance individuals ranging from 2-12% and more frequent individuals from 17-88%. Hence, those attending on more than 15% of nights within a period were defined as frequent attenders, and those attending less than 15% as infrequent attenders. Seasons were defined as: spring, March–May; summer, June–August; autumn, September–November; and winter, December–February.

Statistical analysis

We carried out a binomial generalised linear mixed effect model with attendance (0 = no attendance, 1 = attendance) as the dependent variable. In the model, we included the three-way interaction between season (spring, summer, autumn, winter), sex (male, female) and whether they were frequent attenders or infrequent. Individual ID and year were included as random effects. Post hoc pairwise Tukey tests were conducted between seasons for each sex and between sexes for each season. Significance was adjusted for multiple testing, with α=0.05. Post hoc testing was carried out separately for frequent and infrequent attenders. All statistical analyses were run in R version 3.2.1 (R Development Core Team 2015) using *lmer* function from the LME4 package (Bates et al. 2015). Post hoc analysis carried out using the LSMEANS package (Lenth 2015).

Results

In total, 34 foxes were recorded as attending. We collected data across 63 months (1 January 2007–31 March 2012) from 34 foxes (23 females, 11 males). In total, there were 1917 days, with 5,020 observations of visiting foxes during about 22,000 h of recording.

There was a significant three-way interaction between sex, whether attendance was frequent or infrequent, and season (Table 1).

Among frequent attenders, female attendance was significantly highest in spring and lowest in autumn compared to other seasons (Figure 1). Male attendance was lowest in autumn (Figure 1). Females had significantly higher attendance than males in spring, but not in any other season (Figure 1).

Among infrequent attenders, females attended significantly more during autumn and winter, whereas males attended more consistently year-round, though slightly more often in autumn (P=0.089; Figure 2). Females had higher attendance than males in autumn, but not significantly in other seasons (Figure 2).

Discussion

In general, females had higher feeding site attendance than males. For frequent attenders, differences were greatest during spring. This presumably was because of increased food requirements during lactation and cub rearing. Female red foxes are known to show reduced movements during this time (Travaini et al. 1993; Doncaster & Macdonald 1997; Iossa 2005) and so consistent feeding sites may be important during this period. Infrequent female attender's attendance was lowest in spring and summer.

Interestingly, frequent attenders of both sexes showed a decline in attendance during autumn. This is also the season with the least scavenged meat in urban fox diet (Saunders et al. 1993). This change in diet and decline in attendance could be for either or both of two reasons. Firstly, as fruit is an important component of fox diet during autumn (Saunders et al. 1993; Baker & Harris 2008), this may reduce the need to attend the feeding site. Secondly, individuals may be engaged in other activities and reduced attendance at a feeding site may be simply because time is spent elsewhere in the territory. For example, males increase urine marking rate during autumn (Fawcett et al. 2013), possibly because intrusion by non-residents increases during this period.

Infrequent attenders were observed year-round but, for females, least often during spring and summer. This is consistent with trapping data showing fewest intruding individuals in summer (Baker et al. 2001). Highest attendance for female infrequent attenders was in autumn and winter. This is perhaps unsurprising as this is the main period for dispersal (Soulsbury et al. 2011). Interestingly, rates of observation were not significantly higher for males in autumn and winter. This period coincides with the dispersal for juveniles and breeding season for adult males, leading to high rates of males making extraterritorial movements in search of matings (Baker et al. 2001; Soulsbury et al. 2011). One key difference may result from motivation, with the intruding males seeking reproductive opportunities and not food, which does not translate into visits to feeding sites. In addition, females in neighbouring groups are typically closely related through more limited dispersal distances (Iossa et al. 2009). Therefore intruding females may be more related to residents and so more tolerated.

Conclusions

Foxes showed seasonal variation in their feeding site attendance. For frequent attenders, females had highest attendance during spring presumably because of food needs of dependent young, whereas frequent attenders of both sexes reduced attendance in autumn. Attendance by female infrequent attenders was highest during autumn and winter, coincident with the dispersal period. Fox feeding site attendance seemed most likely driven by intrinsic needs and possibly by seasonal food variation in the local environment.

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Figure 1: Mean ±95%CI proportion individual attendance (N visits/N total nights filmed) by frequently attending males (filled square) and females (open squares) in relation to season.

Figure 2: Mean ±95%CI proportion individual attendance (N visits/N total nights filmed) by infrequently attending males (filled square) and females (open squares) in relation to season.

Table 1: *F* and *P* values for binomial GLMM.

Parameter	**F**	**p**
Sex[1]	6.49	<0.001
Attender[2]	19.73	<0.001
Season[3]	58.84	<0.001
Sex x Attender	0.00	0.472
Sex x Season	12.50	<0.001
Attender x Season	69.30	<0.001
Sex x Attender x Season	23.84	<0.001

[1]male/female, [2]frequent/infrequent, [3]spring/summer/autumn/winter

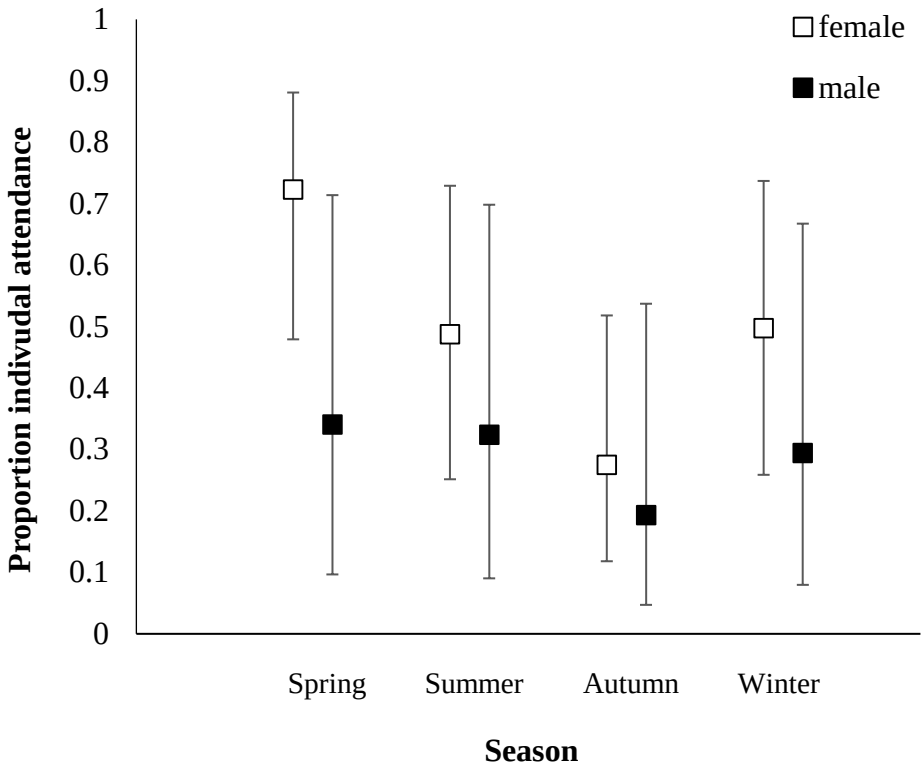
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Proportion indivudal attendance
female
male
Spring
Summer
Autumn
Winter
Season

Figure 1

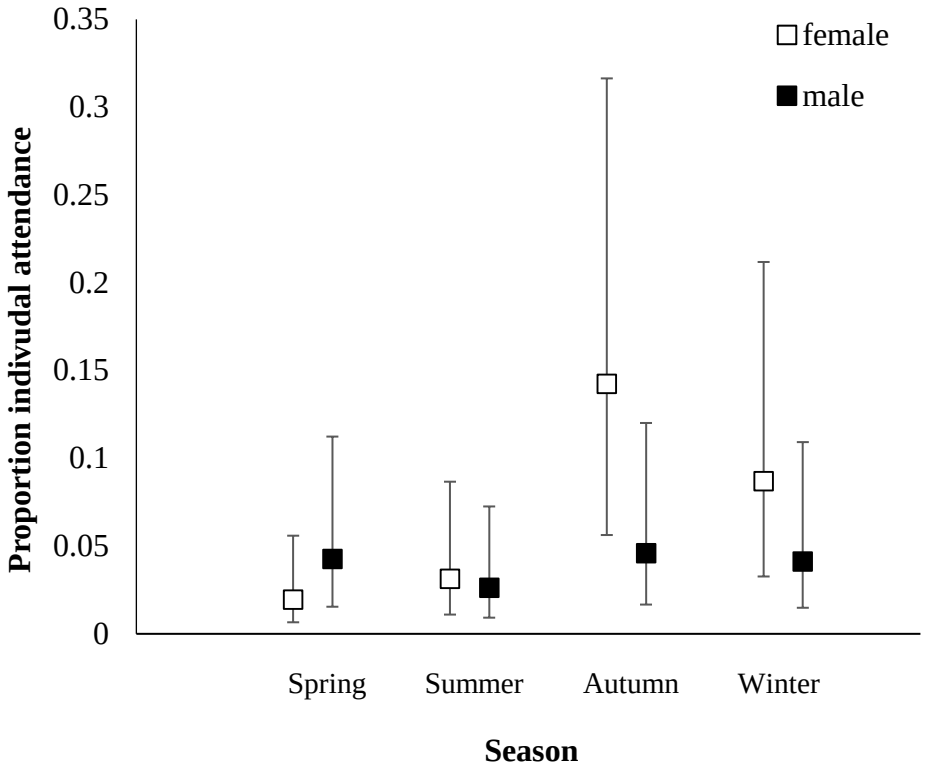
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Proportion indivudal attendance
female
male
Spring
Summer
Autumn
Winter
Season

Figure 2