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The relationship between hunting methods and sex, age and body weight in a non-trophy animal, the red fox

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Abstract. Recently, hunting has represented a major source of mortality in game animals, including red fox, *Vulpes vulpes*, populations. Data from hunting studies have been used to explain evolutionary changes (body size, dental structure) in fox populations; however, knowledge of potential sources of bias in these kinds of data is lacking. Moreover, nature and game managers as well as conservationists have recently been seeking methods to limit European fox populations, which are increasing. In the present study in Polish farmland, we show that three different hunting methods (individual – lying in wait, with dogs at dens, with beating undergrowth to flush out foxes) resulted in differences in the age, sex ratio and body size of shot foxes. Taking account of seasonal differences in hunting methods used, shooting assisted by beating gave a higher proportion of male foxes, whereas individual hunting resulted in smaller foxes in shot samples. Hunting with dogs resulted in heavier female foxes, with the results being skewed towards females. Thus, this method may help limit the breeding capacity of a population and is recommended to assist in the control of red fox populations, at least in farmland areas.

Introduction

Human exploitation is known to be the main limiting factor for many vertebrate populations, especially for game animals (e.g. Rowcliffe *et al*. 2003). For some species, human exploitation via hunting plays a special role. A good example is the hunting of red foxes, *Vulpes vulpes*, which is a long tradition in Europe and whose effect on the control of fox populations has recently been discussed (Pardo and Prato 2005; Ewald *et al*. 2006). The recent discussion on red fox hunting in the popular media has been emotive and polarised, with animal welfare and animal rights groups on one side, and hunters and pragmatic conservationists on the other (Pardo and Prato 2005; Ewald *et al*. 2006).

A better understanding of the process of fox hunting (harvesting) is required for three main reasons. First, hunting represents a major source of mortality in many red fox populations (Goszczyński 1989; Aebischer *et al*. 2003; Ewald *et al*. 2006). Though the dynamic effect of hunting is well studied, selective harvesting may also put strong selection pressures on specific life-history traits (Coltman *et al*. 2003). Second, data derived from harvesting are frequently used in research, e.g. in explaining microevolutionary processes (Szuma 2003; Yom-Tov *et al*. 2007). Studies on ungulates, hunted for trophies, show that it is important to understand the harvesting process as a potential source of bias in morphometric measurements and age structure of the local population (Martínez *et al*. 2005; Mysterud *et al*. 2006). However, as far as we are aware, there is no information on the differences between hunting methods used to kill game animals not used as trophies, and those used to control their population. The red fox is a good example of an animal hunted mainly as a pest in farmland areas, without the emphasis on trophy hunting (Aebischer *et al*. 2003; Pardo and Prato 2005; Ewald *et al*. 2006). Third, in recent decades the numbers of red foxes have increased rapidly in parts of Europe, often as a consequence of vaccination programs following an outbreak of rabies, human abandonment of the countryside and dump proliferation (Chautan *et al*. 2000). In consequence, foxes have had a strong detrimental influence on small game birds and mammals, including endangered species, directly or indirectly via habitat change (Tryjanowski 2000; Tryjanowski *et al*. 2002; Langgemach and Bellebaum 2005; Schwarz *et al*. 2005; Ewald *et al*. 2006). Moreover, throughout Europe, the red fox poses a range of other potential management problems, including the transmission of diseases such as rabies and echinococcosis, and predation on livestock. Therefore, the reduction and change in the demographic structure of red fox populations may be the key measures of the success of different hunting methods.

We predict that different hunting methods result in differences in the age and sex structure, and even in the body weight, of shot red foxes because they focus on exploiting different fox behaviour or different habitats (Yoneda and Maekawa 1982; Kay *et al*. 2000). Males would be more likely to be shot by all methods because they are more mobile than females and, moreover, because females spend a longer time in safe places such as dens, e.g. tending to their cubs (Goszczyński 1977; Voigt and Macdonald 1984). In Europe, red foxes mate in January (winter) and cubs are born in April (spring), becoming independent in August (summer). Body weights may differ among methods. Some methods, particularly beating, which covers a large area during a single day, is more likely to exploit resting, fully fed individuals than hunting at a single focal point, which may focus

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on mobile foraging foxes (cf. Goszczyński 1977; Voigt and Macdonald 1984).

Therefore, the present study was set to examine very simple descriptors (body mass, age and sex), taking account of inter-seasonal differences, to test for differences among samples of red foxes killed by the following three popular hunting methods: the hunter as an individual lying in wait (e.g. near dens), with dogs at dens and with beating. We also discuss the potential of different hunting methods for management.

Material and methods

Study area

The study was carried out in the experimental area (~100 km^2) of the Polish Hunting Association Research Station at Czempiń, western Poland (52°08′N, 16°44′E), a typical farmland region (70% arable), with cereals as the main crop. In this area, the red fox breeds mainly in small forest patches, ditches and other marginal habitats, although recently has begun to live in open arable fields (Panek and Bresiński 2002). The spring density of red foxes in the study area averaged 1.0 individual km^{-2} in the late 1990s (Panek and Bresiński 2002).

Data on shot red foxes

We obtained the following data on 2125 red foxes harvested between 1965 and 2008: the date of shooting, the gender of the corpse, assignment to either juvenile or adult class (recorded for 64%, according to teeth criteria – Goszczyński 1989), the weight to the nearest 0.1 kg (recorded for 67%) and the method of hunting (for 77% of the corpses, see below). The bulk of weight records (1280 of 1470, 87%) were made between 1997 and 2007; hence, the analyses of body weight are restricted to these years only. The first and last years (1965 and 2008) do not represent complete calendar years ($n = 8$ and $n = 29$ corpses respectively).

In the study area, fox shooting was permitted year-round until 2000, whereas in subsequent years the period for hunting was restricted to between summer (July–September) and late winter (December–February) and more recently it spanned from the beginning of July to the end of March. However, in the whole study period foxes were shot mainly in late autumn and winter (69% were shot from October to March). The most frequently used methods of hunting were: (1) individual – lying in wait for individuals entering the area (mainly in the morning or evening; 51% of the cases where the method was recorded); (2) with dogs – using dogs to flush out foxes from their dens or other hiding places for shooting (31% of the recorded cases); (3) with beating – using human beaters to flush out foxes (mainly in woods) for shooting (17% of the recorded cases). A few foxes (<1%) were taken by other means and were excluded from the analyses. Methods were used differentially across the seasons (χ^2 analysis of the frequency of methods by quarter of the year: d.f. = 6, $\chi^2 = 804.81$, $P < 0.001$, see Table 1).

Statistical analyses

Analyses were conducted with the Minitab (www.minitab.com) statistical package. Numbers of foxes in different categories were compared with χ^2 goodness-of-fit tests. Data on body weights were analysed with a general linear model, taking into account the factors year, season (the four quarters JFM, AMJ, JAS, OND), sex, age and hunting method, and all interactions between the last three factors.

Table 1. Number of foxes harvested by different methods for the four quarters of the year

Method	Jan.–Mar.	Apr.–June	July–Sep.	Oct.–Dec.	Total
Individual	227	30	411	156	824
With dogs	316	20	3	166	505
With beating	41	0	0	237	278
Total	584	50	414	559	1607

Results

Red foxes hunted by different methods differed in both age (d.f. = 2, $\chi^2 = 30.89$, $P < 0.001$, $n = 1270$) and sex ratio (d.f. = 2, $\chi^2 = 19.93$, $P < 0.001$, $n = 1607$) (Fig. 1). Because of seasonal differences in the use of methods (see above) the age and sex ratio were also examined with the animals from October–March, with the same conclusions for both the age (d.f. = 2, $\chi^2 = 10.91$, $P = 0.004$, $n = 844$) and the sex (d.f. = 2, $\chi^2 = 19.59$, $P < 0.001$, $n = 1143$). Hunting with dogs resulted in more adults and more females than expected from overall figures.

The analysis of body weight revealed significant differences among the years ($P = 0.002$) and seasons ($P < 0.001$, with body weights greater in the October–March period), between the sexes ($P < 0.001$, males heavier), between the age groups ($P < 0.001$, adults heavier) and among the hunting methods ($P < 0.001$). Body weights (least square mean ± s.e.) for the three methods were 5.45 ± 0.05 kg for individual hunting, 5.74 ± 0.06 kg for hunting with dogs and 5.40 ± 0.09 kg for hunting with beating. Of the interaction terms, sex × age ($P = 0.040$) and age × method ($P = 0.001$) were both significant whereas sex × method ($P = 0.66$) and sex × age × method ($P = 0.91$) were not. Least square means are given in Table 2. Hunting with dogs yielded foxes with a larger body weight than average, particularly for juvenile animals.

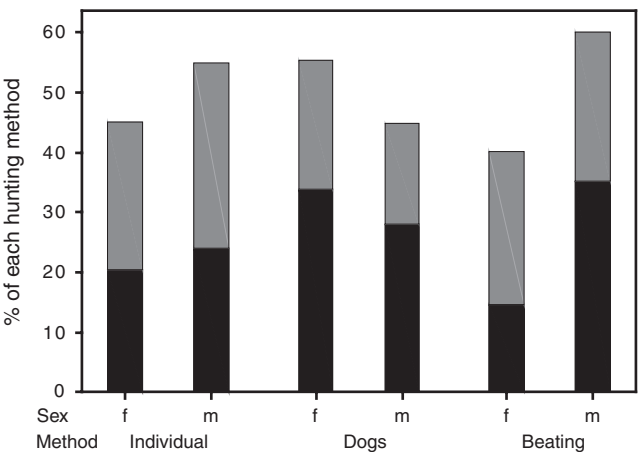

Fig. 1. The differences between age and sex classes in red foxes shot by the three hunting methods. Data are expressed as the percentage of the number shot by each method, adult = black bar, juvenile = grey bar.

Table 2. Comparison of body weights (least square means ± s.e., kg) obtained from the GLM analysis (see Materials and methods) for the three hunting methods in each of the age and sex class during 1997–2007
Sample size is given in parentheses

Method	Adult		Juvenile	
	Female	Male	Female	Male
Individual	5.48 ± 0.07 (142)	6.52 ± 0.08 (170)	4.52 ± 0.07 (172)	5.28 ± 0.07 (218)
With dogs	5.62 ± 0.18 (124)	6.58 ± 0.10 (106)	5.00 ± 0.09 (79)	5.76 ± 0.11 (65)
With beating	5.45 ± 0.17 (22)	6.34 ± 0.14 (46)	4.57 ± 0.13 (40)	5.23 ± 0.14 (40)

Discussion

Different hunting techniques and even different sorts of hunters may result in different selective pressures on mammals, e.g. in trophy hunting (which affects the hunting technique), the time spent hunting and the social status of a hunter may vary (Coltman *et al*. 2003; Martínez *et al*. 2005; Mysterud *et al*. 2006; Milner *et al*. 2007). However, we have shown here that hunting methods play an important role even when the target species is not hunted as a trophy. We found that the three hunting techniques used on red foxes resulted in significantly different age and sex ratios, and body sizes of the shot animals. The methods were not used equally throughout the year. Hunting with beating and hunting with dogs were more popular in winter, when foxes are both more likely to be encountered and more easily tracked because of prints; this may have resulted in differences in the sex, age and body size of harvested red foxes. Methods used in late summer are more likely to encounter juveniles than at other times of the year. However, even when seasonal influences were taken into account, the differences among methods still existed.

The dynamics of red fox populations are strongly related to their demographic make-up (Heydon and Reynolds 2000*a*; Rushton *et al*. 2006) and may be modified by different population-management strategies (Heydon and Reynolds 2000*b*; Ewald *et al*. 2006). Here, we have demonstrated how different management and hunting techniques can influence the sex and size of shot foxes (see also Yoneda and Maekawa 1982; Kay *et al*. 2000). We do not know whether the use of any of the three methods results in accurate reflection of the demographics of the whole population, even though each method appears to select certain types of fox.

To be selective, there must be variation in traits among individual animals, and there must be the possibility, consciously or subconsciously, for the hunter to be selective (Milner *et al*. 2007). This may be difficult in practice; however, our analysis suggests a solution: the demographic structure of local red fox populations may be modified just by using different hunting techniques. For example, if the impact of foxes on birds is mainly by solitary males foraging in open fields (Panek and Bresiński 2002; Gołdyn *et al*. 2003; Schwarz *et al*. 2005), individual hunting and beating may be the suggested hunting techniques to reduce this impact. Whereas if the presence of family dens in arable fields has a negative impact on breeding birds, the best strategy may be to use dogs for hunting and thus cull more adult females. The same is probably true for red fox individuals spending time in dens or resting places. Therefore, successful management by hunting may need identification and focus on particular sex and age categories (the latter trait related to body mass) (see also Reynolds and Tapper 1996; Schwarz *et al*. 2005). Overall, in Polish farmland conditions, hunting with dogs resulted in significantly heavier foxes and more females. Thus, this method may be recommended to assist in the control of red fox populations.

Clearly, long-term monitoring of individuals is the most appropriate way of getting a good sample of life-history data. Such datasets are few, deriving typically from museum collections, and are also collected from hunters or other sources such as road kill (Szuma 2003; Yom-Tov *et al*. 2007). Data from other sources are thus required to understand ecological change in systems where such data cannot be collected, and hunting often provides data from vast areas and across long time frames. We concur with other authors (Martínez *et al*. 2005; Mysterud *et al*. 2006; Milner *et al*. 2007) that knowing, and possibly explicitly modelling, the bias in records, regardless of how it arises, is the way forward; consequently, hunting data can be an enormously important contribution to life-history studies. Indeed, in the present study, the differences between body weights were broadly consistent across the age and sex classes, suggesting little bias when data from only one source are used (Kay *et al*. 2000).

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