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The Role of the Red Fox as a Predator of Species of Human Concern in a Mediterranean Rural Habitat: A Case Study[1]

Jacopo G. Cecere[a], Marco Cianchetti Benedetti[b], Ilaria Guj[c], and Simona Imperio[b, *]

[a]*ISPRA—Institute for Environmental Protection and Research, via Cà Fornacetta 9, 40064 Ozzano Dell'Emilia (BO), Italy*

[b]*RicercaFauna, via Caio Canuleio 83, 00174, Roma, Italy*

[c]*Monti Simbruini Regional Park, via dei Prati 5, 00020, Jenne (RM), Italy*

**e-mail: simona.imperio@libero.it*

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Abstract—The red fox (*Vulpes vulpes*) is generally considered a pest species, especially in rural habitats where it is perceived as a predator of livestock and game species. In many countries, population-control programs are carried out to prevent predation on species of human concern. However, most of these programs occur without an analysis of the real fox impact. This study analyzed the diet of red foxes inhabiting a farmland area characterized by the presence of both free-ranging livestock and game species. We analyzed a total of 147 scats belonging to 32 food samples. Invertebrates represented the main food category (recorded on 66% of food samples), followed by fruit and small mammals, both recorded on 59% of food samples. The seasonal variation of the diet matched the availability of food resources, as demonstrated by the outcome of small mammal trapping activity in the area. The livestock consumption regarded almost exclusively carrions, since only hair of adult sheep were recorded with high frequency. Wild boar hair were found in two food samples, lamb and hare hair were found in only one. Our study showed an easy protocol to assess the role of red fox as a predator of livestock and game species before planning management actions. In the analyzed farmland, for instance, a population-control program should not be justified despite the presence of lambs, piglets, hares and pheasants.

Keywords: diet, farmland, lamb, pest, small mammals

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The red fox (*Vulpes vulpes*) is a generalist predator, common and widespread in Europe. It occupies several habitats including farmlands, where it usually reaches high densities (Panek and Bresinski 2002). The fox is generally considered to be a pest species, especially in rural habitats, since it is a potential predator of livestock and game species (Heydon and Reynolds 2000; Moberly et al., 2003). As a consequence, population-control programs and management plans are carried out in many countries. Lethal techniques represent the main method of control, although nonlethal techniques, such as exclusion fencing, livestock housing, or guard animals are also used to manage fox impacts (Harding et al., 2001; Morberly et al., 2004, Saunders and McLeod, 2007). In Italy, provincial administrations addressed more than 160 requests for an expert opinion regarding the implementation of fox control programs to the National Institute for Environmental Protection and Research (ISPRA, pers. com.) between 2008 and 2011. However, most population-control programs occur without an analysis of the real fox impact. A specific investigation of the diet at a local scale and an assessment of the effective role of the fox as a predator of particular species should be carried out before the planning of any action of control. The red fox has indeed a good ability to track the variation in food availability (Cavallini and Lovari, 1991), hence its diet can vary drastically among areas. Moreover, population-control programs are costly and their efficiency is generally low at the medium and long term, because of the immigration and of the compensatory potential in breeding of the species (Harding et al., 2001; Baker and Harris, 2006; Gentle et al., 2007). Finally, in many cases, the control of foxes through lethal techniques includes the use of dogs which enter dens generating potential disturbance on other burrowing species (e.g. crested porcupine (*Hystrix crestata*) and badger (*Meles meles*)), particularly during their reproductive phases. This study analyzed the diet of red foxes in a farmland located near Rome, which includes habitat types (crops, pastures, natural and artificial woods, Mediterranean maquis) similar to the ones where fox population controls occur, characterized by the presence of free-ranging livestock (sheep and cows) and game species, namely wild boar (*Sus scrofa*), European hare (*Lepus europaeus*), and pheasant (*Phasianus colchicus*). The goal of the study was the assessment of the effective

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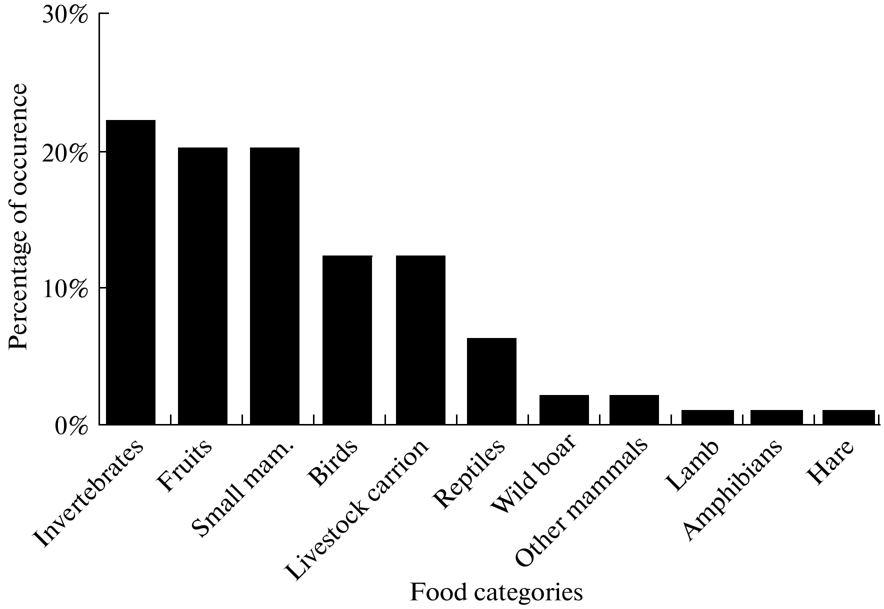

Overall diet composition of red foxes as shown by the percentage of occurrence of each food category, expressed as a percentage of the total number of occurrences of all food categories.

role of the fox as a predator of animals of human concern in a typical Mediterranean habitat.

The study was carried out in Castel di Guido, a 2500 ha farm located 8 km from Rome (Italy). It is a typical Mediterranean rural landscape characterized by cultivated fields (*Triticum* sp. and *Medicago sativa*), large grazing lands (with cows and sheep) and wood patches (mainly *Quercus ilex* and *Q. pubescens*).

Scat collection was carried out monthly from September 2007 to August 2008 within three sampling areas of 10 ha, and located at least 1.5 km from each other. In order to avoid pseudoreplication inconveniences, all scats collected during the same monthly excursion and within the same area were regarded as one food sample. Each scat was examined carefully to find hair, bone fragments, feathers, insect fragments and vegetal remains (seeds etc). Hair were identified through the examination of scale patterns, cross-section and medulla types, according to Teerink (2004) and De Marinis and Agnelli (1993), and using a reference collection of mammal hair belonging to known species present in the study area. A collection of seeds obtained by fruits collected in the area was used to identify vegetal remains. Operator (MCB) ability was verified through a blind test, during which he analyzed hair known only to the other researchers. The test was repeated with 40 random samples each time, until achieving at least 95% of success. All food items found in the scats were classified into 11 categories: small mammals, adult livestock (sheep, cow, horse), lamb, hare, wild boar, other mammals, birds, reptiles, amphibians, invertebrates, fruit, and vegetables. As suggested by Ciucci et al. (1996), frequency data were calculated as percentage of occurrence (PO), where the frequency with which each food category occurs was expressed as a percentage of the total number of occurrence of all food categories. To compare seasonally varying diet compositions we analyzed the five main categories (PO > 10%) of the overall diet composition and we assembled all minor categories into one group.

We estimated the seasonal relative abundance of small mammals in the study area by trapping and marking them with ear-tags. We carried out one trapping session per season. During every trapping session, which lasted three days, we placed 36 longworth traps in pairs along three transects, with a distance of 10 meters between every pair, during three days. We used the minimum number known alive (MNKA) per season as an abundance index for small mammals (following Wolff, 1996). We also estimated small mammal abundance using Lincoln–Peterson mark–recapture methods (Lincoln, 1930), but due to the low number of captures and to the lack of convergence, many estimates could not be obtained. However, previous studies have shown that count data are likely to perform as well as mark–recapture estimates when the trapping protocols and study plots remain constant (Slade and Blair, 2000), thus the MNKA was used in the following analysis.

Fisher's Exact Test was used to test for differences in the fox's diet composition between seasons and to compare seasonal patterns of small mammals recorded by trapping and in the fox's food samples.

We analyzed a total of 147 scats belonging to 32 food samples. Nine food samples were collected in

Seasonally percentage of occurrence (po) of each main category (overall PO > 10%—figure) or items belonging to minor categories (overall PO ≤ 10%), assembled in the category named "Other". Amount of food samples (fs) and scats (sc) including each food category

	Autunm			Winter			Spring			Summer		
	po (%)	fs	sc	po (%)	fs	sc	po (%)	fs	sc	po (%)	fs	sc
Invertebrates	*25*	*9*	*27*	*21*	*4*	*6*	*5.6*	*1*	*1*	*33.3*	*7*	*15*
Fruits	*25*	*9*	*50*	*15.7*	*3*	*6*	*0*	*0*	*0*	*33.3*	*7*	*26*
Small mam.	*11.1*	*4*	*7*	*26.3*	*5*	*8*	*38.9*	*7*	*12*	*14.3*	*3*	*4*
Birds	*11.1*	*4*	*4*	*5.3*	*1*	*1*	*16.7*	*3*	*3*	*14.3*	*3*	*7*
Livestock carrion	*8.3*	*3*	*4*	*21.1*	*4*	*7*	*22.2*	*4*	*4*	*0*	*0*	*0*
Other	*19.4*	*7*	*7*	*10.5*	*2*	*2*	*16.7*	*3*	*3*	*4.8*	*1*	*2*

autumn (Sep–Nov), seven in winter (Dec–Feb), eight in spring (Mar–May) and eight during the summer (Jun–Aug). Each food sample was composed on average of 2.96 ± 0.24 food categories. The percentage of occurrence of each food categories is reported in figure. Invertebrates, which included insects and snails, were recorded on 66% of food samples and they represented the main food category, followed by fruit (*Prunus spinosa*, *Rubus* sp. and a few occurrences of apples/pears) and small mammals (*Mus domesticus*, *Rattus* sp., *Apodemus* sp., *Microtus* sp. and *Crocidura* sp.), both recorded on 59% of food samples. Hair belonging to adult sheep were found in 11 food samples, one of them also containing cow hair. All these cases were considered to refer to feeding on carrions. Wild boar hair were found in two occasions: one sample contained hair of an adult individual and the other of a piglet. Lamb and hare hair were found only in one food sample each. The category "other mammals" included one sample of coypu (*Myocastor coypus*) and one of weasel (*Mustela nivalis*). We found a significant difference in diet composition among seasons (Fisher's Exact Test: $P = 1.624E^{-13}$; $p = 0.03$; $n = 93$). Table shows the number of food samples including each group of food items per season.

During the small mammals trapping sessions we obtained a total of 44 captures, involving 6 species (*A. flavicollis*, *A. sylvaticus*, *R. rattus*, *M. domesticus*, *M. savii*, *C. suaveolens*). Most individuals were trapped in winter and spring (MNKA = 10 and MNKA = 9, respectively), followed by autumn (MNKA = 7) and summer (MNKA = 3). The seasonal pattern of small mammals captured did not differ to the pattern recorded in food samples (see table) (Fisher's Exact Test: $P = 0.02$; $p = 0.88$; $n = 48$).

The overall diet of red fox in the study farmland area was based mainly on invertebrates, fruit and small mammals. Invertebrates are consumed from summer to winter, while fruit are consumed essentially in summer and autumn. Small mammals were predated mainly in winter and spring when they are more abundant and, at the same time, fruits are scarce or completely absent, and invertebrates are less consumed. The fructification peak of *Robus* sp. is, in fact, in August, while the peak of *P. spinosa* is in September–October; in spring fruit are completely absent in the study area. In accordance with other studies (Sidorovic et al., 2006; Dell'Arte et al., 2007), red foxes switched their diet seasonally on more abundant and easier achievable food resources, as are fruit in summer and autumn, and small mammals in winter and spring.

The livestock consumption regarded almost exclusively carrions, since only hair of adult sheep were recorded with high frequency, and we can exclude a direct predation by fox. Despite the fact that sheep carrions are rather abundant in the area they represented only a minor food resource for red fox in this farmland, as did birds and reptiles (figure). In our case study we recorded only one food sample containing lamb hair. This contrasts with observations in several farmlands in UK where foxes are known to usually feed on lambs (see Moberly et al., 2003 and references therein). The same was recorded for hare and wild piglet in our study area. Thus, despite some animals of human concern were consumed, we can assert that their consumption was negligible. Our study showed an easy protocol to assess the role of red fox as a predator of livestock and game species before planning management actions. In the analyzed farmland, for instance, a population-control program should not be justified despite the presence of lambs, hares and pheasants.

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REFERENCES

Baker, P.J. and Harris S., Does culling reduce fox (*Vulpes vulpes*) density in commercial forests in Wales, UK?, *Eur. J. Wildl. Res.*, 2006, vol. 52, pp. 99–108.

Cavallini, P. and Lovari, S., Environmental factors influencing the use of habitat in red fox, *Vulpes vulpes, J. Zool.* (London), 1991, vol. 223, pp. 323–339.

Ciucci, P., Boitani, L., Raganella Pelliccioni, E., Rocco, M., and Guj, I., A comparison of scat-analysis methods to assess the diet of the wolf *Canis lupus, Wildl. Biol.*, 1996, vol. 2, pp. 37–48.

Dell'Arte, G.L., Laaksonen, T., Norrdahl, K., and Korpimaki, E., Variation in the diet composition of a generalist predator, the red fox, in relation to season and density of main prey, *Acta Oecol.*, 2007, vol. 31, pp. 276–281.

De Marinis, A.M. and Agnelli, P., Guide to the microscope analysis of Italian mammals hairs: Insectivora, Rodentia, and Lagomorpha, *Ital. J. Zool.*, 1993, vol. 60, pp. 225–232.

Gentle, M.N., Saunders, G.R., and Dickman, C.R., Poisoning for production: How effective is fox baiting in south-eastern Australia, *Mammal. Rev.*, 2007, vol. 37, pp. 177–190.

Harding, E.K., Doak, D.F., and Albertson, J.D., Evaluating the effectiveness of predator control: The nonnative red fox as a case study, *Conserv. Biol.*, 2001, vol. 15, pp. 1114–1122.

Heydon, M.J. and Reynolds, J.C., Fox (*Vulpes vulpes*) management in three contrasting regions of Britain, in relation to agricultural and sporting interests, *J. Zool.* (London), 2000, vol. 251, pp. 237–252.

Lincoln, F.C., Calculating waterfowl abundance on the basis of banding returns, *United States Department of Agriculture Circular*, 1930, vol. 118, pp. 1–4.

Moberly, R.L., White, P.C.L., Webbon, C.C., Baker, P.J., and Harris, S., Factors associated with fox (*Vulpes vulpes*) predation of lambs in Britain, *Wildl. Res.,* 2003, vol. 30, pp. 219–227.

Moberly, R.L., White, P.C.L., Webbon, C.C., Baker, P.J., and Harris, S., Modeling the costs of fox predation and preventative measures on sheep farms in Britain, *J. Environ. Manag.*, 2004, vol. 70, pp. 129–143.

Panek, M. and Bresinski, W., Red fox density and habitat use in a rural area of western Poland in the end of 1990s, compared with the turn of 1970s, *Acta. Theriol.*, 2002, vol. 47, pp. 433–442.

Saunders, G. and McLeod, L., *Improving Fox Management Strategies in Australia*, Canberra: Bureau of Rural Sciences, 2007.

Sidorovic, V.E., Sidorovic, A.A., and Izotova, I.V., Variation in the diet and population density of the red fox *Vulpes vulpes* in the mixed woodlands of northern Belarus, *Mammal. Biol.*, 2006, vol. 71, pp. 74–89.

Slade, N.A. and Blair, S.M., An empirical test of using counts of individuals captured as indices of populations sizes, *J. Mammal.,* 2000, vol. 81, pp. 1423–1435.

Teerink, B.J., *Hair of West European Mammals: Atlas and Identification Key*, Cambridge, UK: Cambridge Univ. Press, 2004.

Wolff, J.O., Population fluctuations of mast-eating rodents are correlated with production of acorns, *J. Mammal.*, 1996, vol. 77, pp. 859–856.