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Sarcoptic mange and other ectoparasitic infections in a red fox (*Vulpes vulpes*) population from central Italy

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ABSTRACT

Fifty red foxes (*Vulpes vulpes*) from the district of Pisa (central Italy) were examined for ectoparasites. Sarcoptic mange was diagnosed on the presence of clearly visible skin lesions with confirmatory demonstration of *Sarcoptes scabiei* at parasitological and histopathological analysis. Ticks and fleas were collected directly from the carcases during *post mortem* examination, fixed and identified by morphological examination. For the detection of ear *Malassezia* and mite infections, cytological and parasitological examinations of ear wax samples were performed. All data were statistically analysed using a $\chi 2$ test with the Yates correction. An overall prevalence of 84% for ectoparasitic infections was found in examined subjects. In regard to isolated ectoparasites, 38%, 8%, 82%, 6% and 8% of foxes resulted positive for *S. scabiei*, *Otodectes cynotis*, *Malassezia* spp., fleas (*Archaeopsylla erinacei*, *Pulex irritans*, *Ctenocephalides canis*) and ticks (*Ixodes ricinus* and *Rhipicephalus sanguineus*), respectively. *Malassezia* ear infection was significantly more prevalent in animals older than 1 year ($P < 0.01$). Prevalence (38%), severity of lesions and poor body conditions observed in most *Sarcoptes*-infected animals indicate that sarcoptic mange should be considered the most important ectoparasitic infection of red foxes in the examined area.

1. Introduction

Red foxes are the most widespread wild carnivores in Italy and the rest of Europe (Magi et al., 2015) and represent a possible reservoir of zoonotic, anthropophilic and domestic animal ectoparasites, such as *Ixodes ricinus*, *Sarcoptes scabiei* and *Pulex irritans* (Márquez et al., 2009; Sréter et al., 2003). In the same way, red foxes may act as reservoirs for vector-borne infections in domestic animals and humans (Márquez et al., 2009; Kaewmongkol et al., 2011; Torina et al., 2013). Among ectoparasitic infections, sarcoptic mange is a well-known cause of severe disease and high mortality rates in red foxes and it is often responsible for a rapid decline in population densities (Sréter et al., 2003; Davidson et al., 2008; Devenish-Nelson et al., 2014; Forchhammer & Asferg, 2000). Available data on ectoparasitic infections of European red fox populations in Italy are very limited. With the exception of a single report on flea species identified in red foxes from southern Italy (Torina et al., 2013) and on sarcoptic mange in red foxes from the western Italian Alps (Balestrieri et al., 2006), informations are almost absent in Italy. The aim of the present study was to investigate ectoparasitic species and prevalence of ectoparasitic infections in a red fox population living in central Italy (Pisa, Tuscany).

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2. Materials and methods

2.1. Study area and population

From January to December 2010, 50 red foxes of both genders (20 males and 30 females) and different ages were examined. All examined subjects were shot during the regular hunting season in the Province of Pisa, central Italy (43°N, 10–11°E), and chilled at 4 °C until examination, that was carried out within 24 h. The sampling area is characterised by large woodlands, farmland and hills with an elevation ranging from 4 m to 576 m above the sea level. With an area of 2,448 km^2 and a total population of 421,642 inhabitants, the area is densely populated (from about 8 to 865 inhabitants/km^2). In this area, red fox population density is of approximately 1.2–1.6 red foxes/km^2 (Verin et al., 2010). Higher fox densities (up to 2.6 red foxes/km^2) are found in hilly and farmland areas often near urban and peri-urban settings (Mazzarone & Poli, 2012–2015). Age determination of red foxes was achieved based on the weight of dried eye lenses as previously reported (Cavallini & Santini, 1995).

2.2. Parasite sampling

All foxes underwent a complete *post mortem* examination during which body score was assessed based on the amount of retrobulbar and perirenal fat and the presence or absence of muscular atrophy. More precisely, fox body condition was scored as 1) excellent—excellent amount of fat and no muscle atrophy, 2) average—medium to small amount of fat and no muscle atrophy, 3) poor—no retrobulbar and perirenal fat and no muscle atrophy, and 4) cachectic—no retrobulbar and perirenal fat with muscle atrophy. Ticks and fleas were collected directly from the carcases at *post mortem* examination. Collected arthropods were fixed in 70% ethanol and identified microscopically with or without Hoyer's solution. For their identification, keys and description reported by Manilla (Manilla, 1998) and Cringoli et al. (Cringoli et al., 2005) for ticks and by Berlinguer (Berlinguer, 1964) for fleas, were used. Cytological and parasitological examination of earwax samples collected by means of cotton swabs were performed in order to detect *Malassezia* and ear mites' (*Demodex* spp. and *Otodectes cynotis*) infections, respectively. Diagnosis of *Malassezia* otitis was achieved when more than 10 blastospores/microscopic field (mean number of 10 fields) at 400× were observed in Diff Quick® (Medion Diagnostics AG, Düdingen, Switzerland) stained smears. Sarcoptic mange was diagnosed based on the presence of clearly visible lesions on the skin with confirmatory demonstration of *S. scabiei* by means of parasitological and histopathological analysis. Skin samples were collected for histopathology at *post mortem* examinations together with other organ samples (liver, spleen, kidneys, lungs and heart), in order to rule out any concomitant diseases that could have affected the body condition score. These samples were fixed in 10% buffered formalin, processed and paraffin embedded for routine histopathology. Four-μm serial sections were cut and stained with haematoxylin-eosin for general examination. A scoring system of distribution and severity of sarcoptic mange associated lesions was obtained based on a previous published classification (Nimmervoll et al., 2013). At histopathological examination of skin samples from subjects with lesions consistent with sarcoptic mange, the presence of bacteria and yeasts was also evaluated. For parasitological analysis of mange infections, microscopic

Table 1
Results of the 19 *Sarcoptes*-positive red foxes (*Vulpes vulpes*) from the Province of Pisa (Tuscany, central Italy) divided according to age (in year), sex, positivity for *Malassezia* overgrowth in ears, body score, presence of *Malassezia* (M) or bacteria (B) in histological sections of skin, gross distribution pattern[a] and gross/histopathological score[b] of *Sarcoptes*-related cutaneous lesions according to Nimmervoll et al. (Nimmervoll et al., 2013).

Fox N°	Age	Sex	*Malassezia* (ear)	Cutaneous gross lesion distribution pattern[a]	Cutaneous gross/histopathological lesion score[b]	*Malassezia* and/or bacteria at histology	Body score
3	<1	M	Pos	1	A	B	2
9	>1	F	Pos	2	B	M, B	3
10	<1	F	Neg	2	B	M, B	3
14	>1	M	Pos	2	A	–	3
21	>1	M	Pos	1	C	–	2
22	>1	F	Pos	2	A	–	3
24	<1	F	Pos	1	A	–	2
25	<1	F	Pos	2	B	M	3
26	>1	F	Pos	3	B	–	3
27	>1	F	Pos	3	C	–	2
28	<1	F	Pos	2	B	M, B	3
31	>1	F	Pos	1	C	M	2
32	<1	M	Pos	2	B	–	3
36	<1	M	Pos	2	C	–	4
37	<1	F	Pos	3	A	–	2
38	>1	F	Pos	2	B	M, B	4
42	<1	F	Pos	2	B	M, B	3
44	>1	M	Pos	2	B	M, B	3
46	>1	F	Pos	1	A	B	2

[a] 1: only tail and/or hind limbs; 2: in addition to the aforementioned regions, the back and/or thorax affected; 3: in addition to the aforementioned regions, neck and/or head involved.

[b] A: early stage (thin crusts, focally extensive distribution, few mites; B: fatal form (thick crusts, hyperkeratosis, lichenification, diffuse distribution, numerous mites); **C**: healing form (alopecia, no crusts, focal distribution, hyperpigmentation, very rare mites).