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The health of wild red and sika deer in Scotland: An analysis of key endoparasites and recommendations for monitoring disease

Monika Böhm [a], Piran C.L. White [a,*], Mike J. Daniels [b], David J. Allcroft [c], Ranald Munro [d], Michael R. Hutchings [e]

[a] *Environment Department, University of York, Heslington, York YO10 5DD, UK*
[b] *Deer Commission for Scotland, Knowsley, 82 Fairfield Road, Inverness IV3 5LH, UK*
[c] *Biomathematics and Statistics Scotland, JCMB, The King's Buildings, Edinburgh EH9 3JZ, UK*
[d] *Animal Health and Welfare, Royal (Dick) School of Veterinary Studies, Summerhall, Edinburgh EH9 1QH, UK*
[e] *Animal Nutrition and Health Department, Scottish Agricultural College, West Mains Road, Edinburgh EH9 3JG, UK*

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Abstract

Monitoring the health of wildlife populations is important for understanding and controlling the risk of infections to livestock, humans and/or other wildlife. In this paper, we analyse the results of surveys of parasites and non-specific signs of diseases carried out on organs from 638 red and 107 sika deer culled in four regions of Scotland between 1991 and 1997. Infections of the lung by *Elaphostrongylus* spp. were significantly greater in red than sika deer. Older animals were more heavily infected with *Elaphostrongylus* spp. and *Sarcocystis* spp., and infections with *Sarcocystis* spp. tended to be heavier in more recent years.

The results suggest that a combination of key indicator parasite species and non-specific signs of disease may be useful for monitoring the health of wildlife populations at a national scale. However, they also demonstrate that such monitoring needs to be long-term, carried out according to standard protocols and at an appropriate resolution to enable integration with data on other potentially influential environmental factors.
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Keywords: Wildlife; Disease; Infection; *Elaphostrongylus*; *Dictyocaulus*; *Sarcocystis*

1. Introduction

There is an increased recognition that wildlife may play a significant role in the epidemiology of new and emerging diseases that pose serious risks to animal welfare (both domestic and wildlife), human health, wildlife conservation and economic productivity (Dazsak et al., 2000; Deem et al., 2001). Monitoring the health of wildlife populations is therefore important (Frolich et al., 2002; Sainsbury et al., 2001), and the threats to human interests are likely to be relatively greater where wildlife populations are increasing.

Many wild deer species in western Europe are increasing in numbers and extending their ranges (Anon, 2004; Gill, 1990; Telleria and Virgos, 1997; Ward, 2005). Maintaining healthy wild deer populations is important with respect to livestock and human health concerns, as well as potential inter-specific transmission to other wildlife populations. However, the maintenance of health in wild deer, as with many other game species, is also important for the benefits that wild deer bring,

* Corresponding author. Tel.: +44 1904 434062; fax: +44 1904 432998.
E-mail address: pclw1@york.ac.uk (P.C.L. White).

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such as revenue from tourism, stalking and venison production.

All species of deer have been found to host a wide range of endoparasites (Putman, 1988). Nematode parasites predominantly affect the gastro-intestinal tract and the lungs (Fletcher, 2002). Gastro-intestinal parasitism is not thought to be a significant problem in wild deer, although it may cause debilitation in conjunction with nutritional stress, other parasites or disease (Fletcher, 2002; Putman, 1988).

Lungworm infection has been most commonly described in deer (Batty et al., 1987; English et al., 1985; Eriksen et al., 1989; Gibbons and Hoglund, 2002; Handeland et al., 2000; Hollands, 1985; Munro and Hunter, 1983; Roneus and Nordkvist, 1962; Valcarcel and Romero, 2002). *Dictyocaulus* spp., probably the most common helminth parasites in deer, cause pathological changes in bronchi and larger bronchioles (Munro and Hunter, 1983), and research has shown that *Dictyocaulus* cross-infection between red deer (*Cervus elaphus*) and cattle is possible (Foreyt et al., 2000; Johnson et al., 2003). Protostrongylid lungworms such as *Elaphostrongylus cervi* have been found to mature in the central nervous system, before migrating to the skeletal muscles (Handeland et al., 2000) where they are mainly found within the connective tissue, usually causing subclinical parasitosis (Hollands, 1985). *E. cervi* eggs and first stage larvae have also been obtained from the lungs of red deer, where they are usually associated with mild diffuse interstitial pneumonia (Hollands, 1985; Rezac and Blazek, 1991). Infection with *E. cervi* is also common in Scottish deer (roe deer *Capreolus capreolus*, red deer and reindeer *Rangifer tarandus*) (English et al., 1985), but other lungworms such as those of the genus *Muellerius* may also contribute (Fletcher, 2002).

Liver fluke is the only trematode parasite causing disease in British deer, and causes mortality in roe deer, although it does not appear to lead to clinical signs in red deer (Fletcher, 2002).

In this study, we analyse data on key indicator parasite loads and non-specific signs of disease in wild red and sika deer (*Cervus nippon*) in Scotland, UK, between 1991 and 1997. The data include levels of infection of *Sarcocystis* spp., *Dictyocaulus* spp. (the lungworm) and *Elaphostrongylus* spp. (the tissue worm). These infections are principally significant from an animal health perspective, although *Elaphostrongylus* has a low pathogenicity in red deer (Miller et al., 2003). Our dataset represents the first attempt to monitor infections of wild deer in the UK over time on such a large scale; previously published work has been based on much smaller samples (English et al., 1985; Munro and Hunter, 1983). The value of such strategies for future monitoring of the health of wild deer is discussed.

2. Materials and methods

The organs of 744 deer (638 red and 107 sika deer) culled from four regions of Scotland over the period 1991–1997 (Fig. 1) were removed on culling and four blocks ($1 \times 1 \times 1$ cm cubes) of heart, lungs and liver were placed in formalin and sent to the Veterinary Laboratory Agency, Lasswade, Scotland, for histopathological examination. All examinations were carried out by the same pathologist.

The intensity of various specific parasitic infections and cellular changes not specific to particular diseases but important as signs of general health, in the liver, lung and heart, were scored on a scale of 0–4. On this scale, 0 represented absence, 1 signified that the parasites or lesions were present but scarce, and 4 indicated that every field contained parasitic elements or cellular changes (Munro and Hunter, 1985). Identification of pulmonary parasites was based on their morphology in tissue sections (Chitwell and Lichtenfels, 1972) and the tissue reactions to pulmonary parasites in red deer (Munro, 1985). The infections and changes recorded are shown in Table 1. Animals were classified by species (SPECIES, red or sika deer), sex (SEX) and age in months (AGE). They were also classified by year of death between 1991 and 1997 inclusive (YEAR, coded 1–7 for analysis) and the region of Scotland from which they were sampled (AREA; Grampian (G), Highland (H), Perth (P) or Strathclyde (S)).

The severity scores were analysed using ordinal regression (GenStat, 2000). This can be thought of as an extension of binomial logistic regression, but here a multinomial distribution is used with logit link function, and the ordered categorical nature of the data is specifically allowed for. Models were fitted to investigate the effects of SPECIES, SEX, AGE, AREA and YEAR. All terms were included together in the models, and changes in deviance were used to establish whether each term was useful after allowing for all other terms. Changes in deviance are approximately distributed according to χ^2 with the relevant degrees of freedom; in the results, deviance ratios (deviance divided by degrees of freedom) are quoted along with the associated *P*-values.

3. Results

The distribution, across species, sex and year, of the 731 deer samples for which complete data were recorded, is shown in Table 2. Severity scores for the different specific infections and non-specific changes found during histopathological examination of the culled deer are presented in Table 3, and the results of the ordinal regression analysis of these data are summarised in Table 4.

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