Biological Conservation 144 (2011) 641–649

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Effects of hunting with hounds on a non-target species living on the edge of a protected area

Stefano Grignolio [a,*], Enrico Merli [b], Paolo Bongi [a], Simone Ciuti [a,1], Marco Apollonio [a]

[a] Department of Zoology and Evolutionary Genetics, University of Sassari, Via Muroni 25, I-07100 Sassari, Italy
[b] Wildlife Service, Province of Piacenza, C.so Garibaldi 50, I-29100 Piacenza, Italy

ARTICLE INFO

Article history:
Received 22 March 2010
Received in revised form 25 October 2010
Accepted 31 October 2010
Available online 15 December 2010

Keywords:
Roe deer
Hunting techniques
Protected area
Hunting with hounds
Conservation policies
Reserve effect

ABSTRACT

The impact of hunting on wildlife is a complex phenomenon which varies in space and across time, and yet limited knowledge is available on it. This is especially the case of the indirect effects of hunting on the behaviour of target as well as non-target species. Here we analyze how hunting affected the spatial behaviour of 62 radiocollared roe deer (*Capreolus capreolus*) in a protected area adjacent to areas where hunting with hounds (target species: wild boar and hares) and stalking with rifles from high seats without dogs (target species: roe deer) were permitted during the hunting season. Our results showed that hunting caused a significant increase in the home range size of monitored deer, as well as a "reserve effect", whereby roe deer used the protected area as a refuge from hunters. These behavioural responses were significant only at times when hunting with hounds was conducted, even though roe deer was not the target species of this technique. Reactions to the perceived risk of predation varied among age and sex classes, with yearling being more sensitive and using the protected area more than adults. As shown in our study, hunting harassment provoked by drives with hounds significantly affects the behaviour of non-target species. Therefore, the use of long-legged hounds represents a variable that should be carefully evaluated by wildlife managers in their management plans and conservation policies, especially when endangered or vulnerable species are present.

1. Introduction

Hunting has been recognized as a crucial factor in the biological and cultural evolution of man (Klein, 1989), whereas limited information is currently available on its ecological effects on prey populations, and, more generally, on biodiversity. The role played by humans in the extinction or reduction of the distribution range of many large vertebrate species is commonly acknowledged.

Several protected areas have been established across the world during the last few decades in order to address the dangers posed by human beings. Undoubtedly, protected areas have contributed to the conservation of several species, and, more generally, of biodiversity (e.g. Caro, 1999). In this regard, it is important to assess how human activities along the borders of protected areas can affect the distribution of species outside as well as inside the reserves. For instance, information is scarce on how certain human activities, including a range of hunting techniques, can result in abnormal concentrations of wildlife in protected areas and related negative effects (e.g., increase in browsing pressure, decrease in soil quality, modification of micro- and macro-invertebrate communities). The impact of human activities on wildlife, and of hunting in particular, is often complex and varies in space and across time, although its actual effects are still poorly understood (Blumstein et al., 2005; Jayakody et al., 2008; Stankowich, 2008). In particular, ungulate population dynamics are greatly influenced by harvesting (e.g. Toïgo et al., 2008), whereas only recently interest increased regarding the effects of hunting on the genetic structure of populations as well as on the distribution of key phenotypes (Allendorf et al., 2008; Coltman et al., 2003).

In this general framework, very little is known about the indirect effects of human harassment (particularly of hunting) on prey behaviour, population dynamics and life history (Milner-Gulland et al., 2004; Proaktor et al., 2007). Several authors argued that hunting is able to shape the fright behaviour of birds (Madsen, 1985; Madsen and Fox, 1995) and mammals (Jeppesen, 1987a,b; Shultz and Bailey, 1978) in response to humans, even though such a response was tested empirically only in recent years and produced heterogeneous findings. Colman et al. (2001) tested the flight distance in reindeer (*Rangifer tarandus*) as a response to human presence and did not find any evidence of it, while, Reimers et al. (2009) showed that reindeer flight-initiation distance increased following the introduction of hunting. A study conducted on roe deer (*Capreolus capreolus*) found that individuals living in

* Corresponding author. Tel.: +39 079228667; fax: +39 079228665.
E-mail address: sgrigno@uniss.it (S. Grignolio).
[1] Present address: Biological Sciences, University of Alberta, Edmonton, Canada T6G 2E9.

0006-3207/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.biocon.2010.10.022

hunting areas seemed to respond more sensitively to man than individuals living in areas where hunting was banned (de Boer et al., 2004). A correct assessment of different forms of wildlife harassment should take into account not only the flight distance (Enggist-Düblin and Ingold, 2003), but also other behavioural responses such as modifications to home range and feeding behaviour (e.g.: Ciuti and Apollonio, 2008; St Clair and Forrest, 2009; Tolon et al., 2009).

There is empirical evidence that hunting with high numbers of men and dogs may have a strong impact on cull intensity as well as on animal disturbance (Sforzi and Lovari, 2000). As some of the traditional hunting techniques employed in central and southern Europe do entail the use of hounds, several authors analysed the influence of hunting with hounds on prey behaviour. In a study on red deer (*Cervus elaphus*), Jeppesen (1987b) recorded and distinguished two behavioural modifications in response to hunting with hounds: the immediate escape, occurring at the beginning of the disturbance, and the late escape, occurring at the end of it. The late escape was shown by animals that were pursued by hounds, but also by animals that were not chased. Also Sunde et al. (2009) showed that hunting disturbance induced prolonged behavioural modification, with red deer hinds showing migration as a general response-type to hunting harassment. As regards ungulates in particular, hunting harassment also modified the habitat selection (individuals spent more time in densely vegetated areas) and encouraged crepuscular and nocturnal rather than diurnal activity (Kamler et al., 2007; Kilgo et al., 1998; Kufeld et al., 1988).

Our study tested the influence of hunting on the spatial behaviour of the most common European ungulate, the roe deer, and considered a protected area (hunting forbidden throughout the year) surrounded by districts where hunting with hounds (target species: wild boar *Sus scrofa* and hares *Lepus europaeus*) alternated with stalking from fixed high seats (target species: roe deer) and no hunting of any kind was permitted for 5 months each year. We adopted two approaches to study how roe deer modified spatial behaviour as a response to these hunting techniques. First, we assessed home range size variation as a response to a set of explanatory variables on a broad scale; second, we computed the probability of a roe deer being outside or inside the protected area according to explanatory variables on a finer scale. Thus, our predictions were as follows:

(1) Due to the hunting harassment occurring outside the protected area, roe deer living outside and on the edge of it were expected to increase mobility and home range size, as well as to find refuge in it.
(2) Hunting with hounds was predicted to significantly affect roe deer spatial behaviour, despite this not being the target species.
(3) Given the differential response to predation risk commonly recorded among sex and age classes in ungulates (Grignolio et al., 2007; Main et al., 1996; Ruckstuhl and Neuhaus, 2005), more sensitive individuals such as females and yearlings were predicted to be more likely than adult males to seek refuge in the protected area, thus taking advantage of the "reserve effect".

2. Methods

2.1. Data collection

The study was conducted in a mountainous area located on the Tuscan slope of the Apennines in the province of Arezzo, Italy (43°48′N, 11°49′E). The borders of the study site (8612 ha) were determined through the Minimum Convex Polygon by computing all roe deer locations collected from 2001 to 2005. A protected area (Oasi Alpe di Catenaia, OAC, 2795 ha) was located within the study site, with non-fenced borders delimited by vertical road signs. The elevation of the area ranges between 300 and 1514 m a.s.l. (Fig. 1), with peaks located within OAC, where snow usually falls from October to April. During this research, the density of roe deer estimated by means of drive censuses performed in forested areas was 21.2 head/km^2 (min = 17.5; max = 25.2) inside OAC, and 44.5 head/km^2 (min = 36.6; max = 51.2) outside OAC.

The habitat composition inside and outside OAC differed (Fig. 1). Outside OAC, deciduous coppice forests (mainly oak, *Quercus spp,* and chestnut, *Castanea sativa*) were prevalent with a harvest frequency of 20 years. These forests were characterised by a high density of young trees, and, as a consequence, by a rich undergrowth vegetation. High deciduous forests (mainly beech *Fagus sylvatica*) and conifer forests (*Pinus nigra, Abies alba, Pseudotsuga menziesii*) characterised by a scarce undergrowth vegetation prevailed inside OAC, where harvest frequency was around

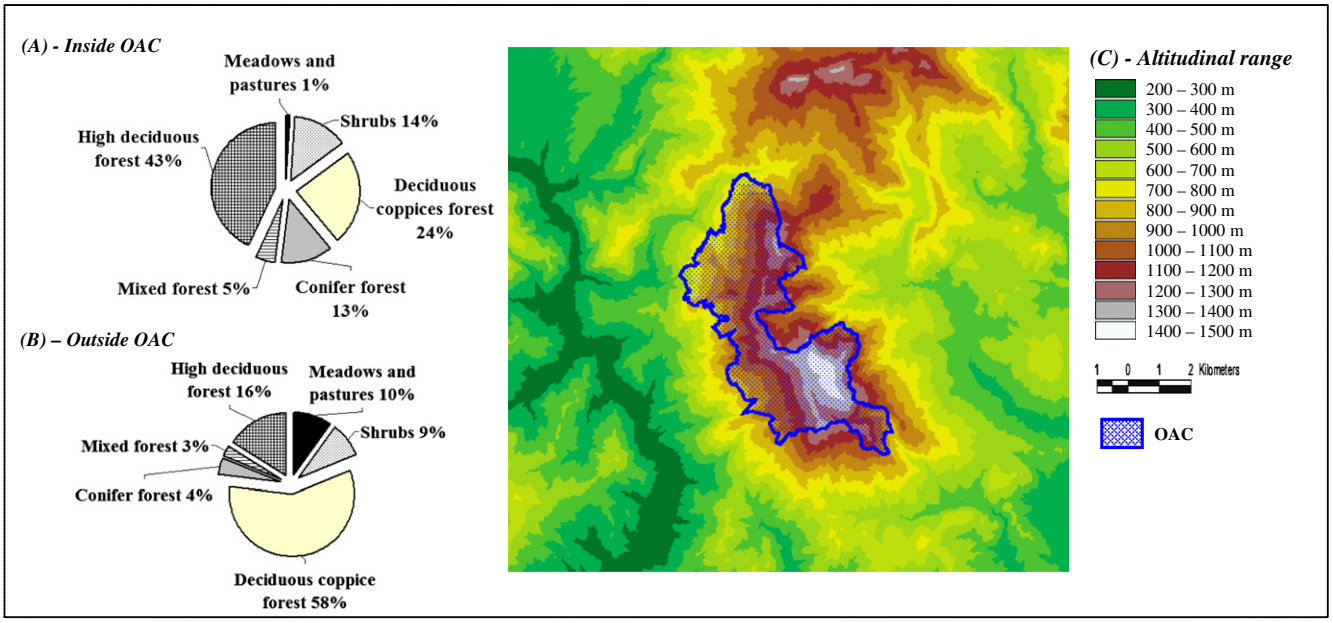

Fig. 1. Habitat composition of the study site, within (A) and outside (B) the protected area "Oasi dell'Alpe di Catenaia" (OAC), and its altitudinal range (C).