
Keywords: 8IT/body condition/Canis lupus/Capreolus capreolus/Cervus elaphus/Malme/marrow fat/predation/red deer/roe deer/wolf

Abstract: The leg bone marrow fat of 11 roe deer (Capreolus capreolus) killed by wolves (Canis lupus) was examined and compared with that of 15 roe deer killed in traffic accidents. Moreover, a sample of 14 red deer (Cervus elaphus) kills was examined. High levels of femur marrow fat (75-100 %) were detected in 45% of the roe deer killed by wolves. The amount of leg bone marrow fat showed a decrease through the winter season, roe deer killed by wolves did not show a significantly lower marrow fat level than those killed in traffic accidents. According to our analyses red deer were in generally poor conditions, and yet such a result cannot be regarded as representative of the average condition of the population.
The physical condition of roe and red deer killed by wolves in a region of the western Alps, Italy

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Received 2 May 2007; Accepted 7 November 2007

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Key words: Canis lupus, Capreolus capreolus, marrow fat, body condition

Introduction

Wolves are thought to capture sick and weak animals in higher proportions than standard individuals of the same population, and the more difficult prey species are to capture, the higher is the proportion of sick and weak preys (Mech 1970, Temple 1987).

Several works have used leg bone marrow fat as an indicator of ungulate nutritional status (Ratcliffe 1980, Fong 1981, Fuller et al. 1986) while numerous researchers found that the marrow fat value is a direct indicator of the total body fat in ungulates (Hout & Goudreau 1985, Watkins et al. 1991, Holland 1992).

Del Giudice et al. (1990) found that the loss of fat stores entailed also a loss of protein and muscle mass in ungulate species. Thus, marrow fat percentage should be viewed as an indicator of fat, muscle and energy depletion, and any level below a threshold of 70–85 % c.a. should be taken to indicate generally poor conditions (Mech et al. 1995).

Numerous researches on the physical condition of wolf kills were conducted in North America and Eastern Europe (Oarma 1984, 1991, Huggard 1993, Husselman et al. 2003, ) but none in Western Europe, Italy included.

The aim of this study was to provide the first data on the body condition of roe and red deer preyed upon by wolves in an Alpine area and, in the case of roe deer only, to compare the conditions of those killed by wolves and those killed in traffic accidents. The study was carried out in a mountainous area where roe and red deer constitute the predominant food items of wolves in winter (Gazzola et al. 2005).

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Study Area, Material and Methods

The study area, 475 km² ranging between approximately 800 and 2,800 m elevation, was located in an Alpine region, within the western portion of the province of Turin (45°05′N, 7°E). The habitat of the area at its lowest elevation consists of a mixture of woods of beech (*Fagus silvatica*), maple (*Acer platanoides*) and birch (*Betula pubescens*) and fields, while between 1,100 and 2,300 m, coniferous forests of pine (*Pinus sylvestris*), spruce (*Picea abies*), and larch (*Larix decidua*) are dominant. Over 2,300 m, Alpine meadows and rocky areas gradually replace the forests. The area is characterized by the presence of six wild ungulates: chamois (*Rupicapra rupicapra*), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), wild boar (*Sus scrofa*), ibex (*Capra ibex*), and mouflon (*Ovis orientalis musimon*).

Data on wolf kills were collected in the study area from November 2003 to April 2004. Snow-tracking surveys were made throughout the study area after 1–2 days of snowfall. This technique enabled us to follow the travel routes of wolves and to search for their kills. Wolf signs on the snow (e.g., presence of blood, signs of a struggle) and the autopsy of carcasses allowed us to distinguish whether wolves had killed a living prey or rather scavenged a carcass. The control sample was constituted by ungulates that had been killed either by cars or trains. The bones of one hind leg of each carcass were removed and marrow samples were taken from the middle part of the femur, metatarsus and tibia. After being weighed, the samples were placed in Petri dishes, oven-dried to constant weight at 70 °C, and their dry weight was expressed as a percentage of fresh weight (Neiland 1970). The t-test for independent samples was used to estimate the difference between the leg bone marrow fat content of wolf kills and that of traffic victims. Specifically, we pooled all the data on femur, tibia and metatarsus marrow fat content for each period. The relationships between marrow fat of each set of bones were calculated using Spearman’s correlation coefficient ($r_s$).

Results and Discussion

A sample of 11 roe deer killed by wolves and 15 killed by cars or trains was analysed. A wide variation in the amount of marrow fat was found in all the leg bones. Percentage of marrow fat varied from 20 to 96% in the femora, from 14 to 93% in the tibiae, and from 29 to 94% in the metatarsi of the roe deer killed by wolves. Percentage of marrow fat varied from 22 to 99% in the femora, from 31 to 99% in the tibiae and from 19 to 99% in the metatarsi of the roe deer killed in traffic accidents.

According to the analyses, the marrow fat content in each set of bones – femur, tibia and metatarsus – was significantly correlated to the marrow fat content in all the other sets (Spearman’s correlation: femur-tibia: $r_s$ =0.828, $P <0.01$; femur-metatarsus: $r_s$ =0.784, $P <0.01$; tibia-metatarsus: $r_s$ =0.852, $P <0.01$).

Roe deer killed by wolves and roe deer killed in traffic accidents did not differ in the average percentage of marrow fat (t-test: $n_{\text{wolf kill}} = 11$; $n_{\text{traffic accident}} = 14$; $t = 1.369$; $P = 0.184$) (Fig. 1), which was higher in the femur than in the metatarsus in both groups. Moreover, bone marrow fat showed a decrease as the cold season progressed (Table 1). The difference between early winter (November-January) and late winter (February-April) was significant (t-test: $n_{\text{Nov-Jan}} = 5$; $n_{\text{Feb-Apr}} = 6$; $t = 3.193$; $P = 0.011$; t-test: $n_{\text{Nov-Jan}} = 10$; $n_{\text{Feb-Apr}} = 4$; $t = 4.517$; $P = 0.001$).
In both periods the percentage of femur marrow fat in the roe deer killed by wolves and in those killed in traffic accidents was similar (t-test \textsubscript{Nov-Jan}: \(n_{\text{wolf kill}} = 5; n_{\text{traffic accident}} = 10; t = 0.591; P = 0.564\); t-test \textsubscript{Feb-Apr}: \(n_{\text{wolf kill}} = 6; n_{\text{traffic accident}} = 4; t = -0.328; P = 0.752\)).

A sample of 14 femur marrow fat of red deer killed by wolves throughout the winter was analysed and compared to the femur marrow fat of roe deer. Most of the red deer killed by wolves showed low levels of fat (0–75 %), while most roe deer were in good physical condition (75–100 %) (Fig. 2). However, the lack of a control sample of red deer did not allow us to test whether there was any selection of red deer by wolves on the basis of body condition.

Most studies have found an increased number of pathologies and poorer body conditions in the wild ungulates killed by wolves (Peterson et al. 1984, Messier & Crete 1985, Huggard 1993). Nevertheless, in other studies conducted on white tailed deer, femur fat levels in wolf kills were higher than or did not differ from those in the population at large (Mech & Frenzel 1971, Fritts & Mech 1981).

**Table 1.** Marrow fat content (%) in the roe deer killed by wolves and in those killed in traffic accidents in Val di Susa during the winter.

<table>
<thead>
<tr>
<th>Winter</th>
<th>Legbone</th>
<th>Wolf n.</th>
<th>Mean</th>
<th>SD</th>
<th>n.</th>
<th>Control Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov–Jan</td>
<td>Femur</td>
<td>3</td>
<td>81</td>
<td>18</td>
<td>10</td>
<td>83</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Tibia</td>
<td>5</td>
<td>86</td>
<td>14</td>
<td>10</td>
<td>92</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Metatarsus</td>
<td>5</td>
<td>92</td>
<td>3</td>
<td>10</td>
<td>96</td>
<td>5</td>
</tr>
<tr>
<td>Feb–Apr</td>
<td>Femur</td>
<td>6</td>
<td>44</td>
<td>26</td>
<td>4</td>
<td>54</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Tibia</td>
<td>6</td>
<td>44</td>
<td>29</td>
<td>4</td>
<td>59</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Metatarsus</td>
<td>6</td>
<td>64</td>
<td>24</td>
<td>3</td>
<td>50</td>
<td>31</td>
</tr>
</tbody>
</table>
The present study found that wolves in the western Alps did not select roe deer individuals in poor body conditions more than standard roe deer individuals. Moreover, what Okarma (1991) had found in the red deer killed by wolves was also observed in relation to the body condition of roe deer, which deteriorated considerably during the winter. However this was found in both the wolf kills and the sample control. Therefore, it might be argued that the body condition of roe deer individuals did not possibly affect the wolves’ choice of the prey. This lack of selection could be explained by several reasons:

i) the elusive and secretive life style of roe deer, their use of habitats with scarce visibility and their small group size, make it difficult for wolves to estimate their body condition;

ii) their scarce mobility in deep snow and on the broken grounds of the Alpine areas makes them, once they have been found, vulnerable to wolf attacks despite their potentially good body condition;

iii) in this study area, roe deer are the second prey in order of importance, after red deer, in the wolf diet. However wolves do not prefer roe deer to other deer and this could be accounted for by the body condition of the prey not being a relevant factor in the wolves’ choice.

Most of the red deer killed by wolves showed lower levels of fat in the femur marrow than roe deer, possibly due to the larger body size and the stronger resistance to winter conditions of red deer. Body condition may have played a role in the choice of the prey by wolves; however, more information on the body condition of red deer in this population are needed to verify such an hypothesis.

Fig. 2. Percentage distribution, over different intervals of fat content in femoral bone marrow, in roe deer and red deer killed by wolves.

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Acknowledgements

We wish to thank Bogumiła Jędrzejewska and Włodzimierz Jędrzejewski (Mammals Research Institute, Polish Academy of Sciences, Białowieża, Poland) for their helpful comments on the early draft of this paper. We are very grateful to Marco Costamagna, Roberto Mussi (Comprensorio Alpino CATO2) for their help in data collection. We would also like to thank the Servizio Tutela Flora e Fauna of Turin Province, and the Corpo Forestale dello Stato for their indispensable collaboration. We thank Andrea Bineilli for linguistic revision. The study was supported by the Turin Province and Piemont Regional Government.

Literature


