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# An analysis of roe deer (*Capreolus capreolus*) traffic collisions in the Belluno province, eastern Italian Alps

L. Dal Compare, E. Sturaro, G. Cocca, M. Ramanzin

Dipartimento Scienze Animali. Università di Padova, Italy

*Corresponding author:* Luca Dal Compare. Dipartimento Scienze Animali, Università di Padova, Viale dell'Università 16, 35020 Legnaro, Italy - Tel. +39 049 8272638 - Fax: +39 049 82722633 - Email: luca.dalcompare@unipd.it.

**ABSTRACT:** Data of roe deer traffic collisions from 1989 to 2004 in the Belluno province were analyzed to describe patterns of road kills by zone, season and sex and to compare resulting annual trends and sex ratios with those estimated for roe deer population. The province was divided in 2 districts on the base of differences in climate, landscape and roe deer population status. Pearson's simple correlation was used to investigate the associations, in the two districts, among road kills data, year, population density, traffic index, and snow depth. Bonferroni's confidential intervals to 95% of significance were used to compare the monthly distributions of collisions between sexes and between districts. In conclusion, the analysis of car accidents may not reflect population trends and sex ratios when traffic rates change and when different ecological factors, others from deer density, influence the probability of deer to incur in a car accident. In addition, differences of accident probability between sexes and months can be found in areas with different landscapes, climates and population structures. These factors should be evaluated in order to manage accident risk and to understand the potential of car accidents records as a tool for monitoring population status.

**Key words:** Vehicle collisions, Road kills, Roe deer.

**INTRODUCTION** – The recent expansion of deer populations in western Europe has led to an increase in deer-vehicle collisions (Groot Bruinderink and Hazebroek, 1996). Therefore, there is a growing interest towards the understanding of factors affecting the risk of accidents (Malo *et al.*, 2004; Seiler, 2005), and the possible use of trends of deer road kills as indicators of population trends (Groot Bruinderink and Hazebroek, 1996). This work produces a preliminary analysis of roe deer traffic collisions collected from 1989 to 2004 in the Belluno province (north-eastern Italian Alps). The province was divided in two districts, contrasting for climate, landscape and roe deer population trends, and data were analysed to describe patterns of road kills by zone, season and sex, and to compare resulting annual trends and sex ratios with those estimated for roe deer population.

**MATERIAL AND METHODS** – The Belluno province covers 3667km<sup>2</sup> in the eastern Italian Alps. For the analyses it was divided in 2 districts (north and south) according to Zannèse *et al.* (2006). The northern district (2090km<sup>2</sup>) is characterised by high elevations (average 1400m a.s.l.), mostly coniferous woods, harsh winters with deep snow, while the southern district (1577km<sup>2</sup>) is characterised by low elevations (average 663m a.s.l.), mostly deciduous woods, and mild winters. A total of 2496 road kills data, obtained from the Corpo di Polizia Provinciale di Belluno and recording municipality, date of accident and sex of deer involved, were used. As an index of traffic intensity trends we used the annual number of registered cars in each district and divided it by the number of 1989. Standardised road kills were obtained by dividing annual actual road kills by the annual traffic index. Roe deer annual population trend in the two districts were estimated (from 1993) with a culling efficiency index (Zannèse *et al.*, 2006), calculated as the number of roe deer shot/100 hunters in the first 2 days of hunting season. Simple correlations between actual road kills, year and annual traffic index, and between standardised annual road kills, year and culling efficiency index were tested. To verify whether road kills were related to snowfalls we obtained from ARPAV - Centro Meteo di Arabba data on average snow depths during the "winters" (October-May) of the study period and correlated them to the standardised road kills of the same time periods. Actual male:female ratios of roe deer population in both districts were estimated from sex composition of record-

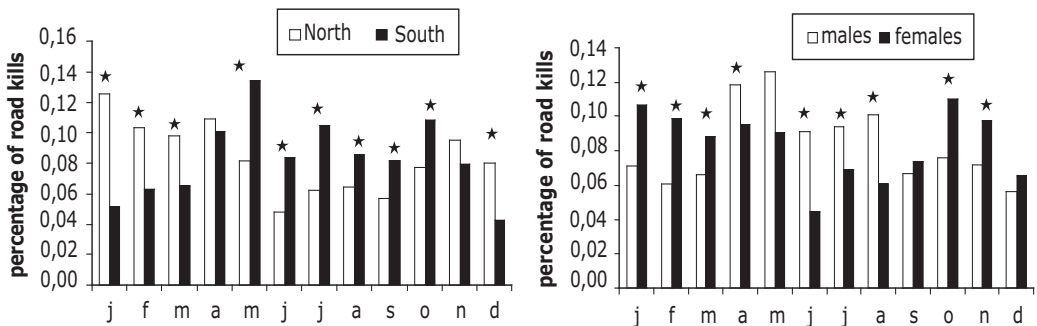
ed roe deer natural mortality (5078 records) and compared with those from road kills with  $\chi^2$  test. Monthly distributions (% of annual) of road kills between sexes and between districts were compared with Bonferroni's confidential intervals to 95% of significance.

**RESULTS AND CONCLUSIONS** – Over the last 16 years, roe deer road kills have been increasing both in the northern and in the southern district, as indicated by the positive correlation with year (Table 1). Also the traffic index was highly correlated to road kills, and, as a results, standardised road kills was correlated with year. Population trends, as indicated by the culling efficiency index, indicated a growth in the southern district, and a decline in the northern (Table 1). Therefore, standardised road kills were positively correlated with population trends in the south, but the opposite was found in the north (Table 1). These results confirm that traffic rise can alter the mortality pressure within a given area (Baker *et al.*, 2004) affecting road kills independently from population density. However, even traffic-corrected data may not represent changes in population trends, as found in the northern district. In fact, factors other than density may influence the probability of collisions, as demonstrated by the high correlation with snow falls in the northern district (Table 1). Heavy snowfalls force deer to concentrate at low elevations along the valley bottoms, where main roads are located. In addition, deer may be attracted to roadsides by food items and by salt used for melting snow (Groot Bruinderink and Hazebroek, 1996). This effect probably varies according to the severity of climate, and in fact it was not detected in the southern district (Table 1). Monthly proportions of deer-vehicle collisions are in accord with this pattern, with higher proportions for winter in the north and for summer in the south (Figure 1a).

Table 1. Values of the simple correlations between parameters used in this study.

Type of correlation	Northern District		Southern District	
	r	P	r	P
Year - road kills	0.78	0.01	0.68	<0.01
Traffic index - road kills	0.76	<0.01	0.70	<0.01
Year - standardised road kills	0.73	<0.01	0.52	<0.05
Year - culling efficiency index	-0.77	<0.01	0.55	0.05
Standardised road kills - culling efficiency index	-0.45	NS	0.56	0.05
Snow depth - standardised road kills	0.65	<0.01	-0.01	NS

Figure 1. Differences of monthly probability of car collisions (% of annual collisions) between districts (1a) and sexes (1b). \* indicate P<0.05 calculated with Bonferroni's confidential intervals.



Population sex ratios (Table 2) are biased towards females, especially in the northern district (Table 2), most probably due to the traditionally higher hunting pressure on males (Ramanzin, 2001). This indicates that sex ratio of road kills is not representative of population sex ratio (Northern district:  $\chi^2=9.45$ ,  $P<0.01$ ; Southern district  $\chi^2=41.21$ ,  $P<0.001$ ), that males have a higher probability of incurring in car crashes than females, and that this was especially true for the southern district.

Table 2. Comparison between population sex ratio estimated from natural mortality records and sex ratio from road kills data in the two districts of the province.

District	Natural mortality		Road kills	
	North	South	North	South
Males:females (n.)	913:1987	809:1369	490:862	591:629
Sex ratio	0.46	0.59	0.57	0.94

Collision probability is influenced by individual mobility, that is maximum during the dispersal phase, in April-July. Dispersal in roe deer is still a largely unknown phenomenon, but it is possibly biased towards males (Liberg *et al.* 1998). In addition, females show the minimum mobility in the period around parturition, that occurs from late May-beginning of June, and during the following first month of kids rearing. Therefore, from April to July, males should be exposed to higher risks of car accidents than females. This suggestion is in accord with the observed pattern of monthly distribution of car accidents between sexes, that was higher for males than females during the dispersal and kid-rearing periods (Figure 1b). The higher probability of males incurring in car accidents in the south than in the north (Table 2) could be due to a higher tendency for males to disperse in this district. Targhetta *et al.* (2005) observed that individual genetic distance of male roe deer was correlated to spatial distance in the north, but not in the south, so suggesting that in this latter district there was no obstacle to gene flow between males, which would be in accord with a greater dispersal tendency.

In conclusion, trends in car accidents may not reflect population trends and sex ratios when traffic rates change and when different ecological factors, others form density, influence the probability of deer to incur in a car accident. Areas with different landscapes, climates and population structures may differ in between sexes and monthly probability of accidents. These factors should be evaluated both in order to manage accident risk and understand to potential of car accidents recording as a tool for monitoring population status.

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