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Can roe deer hunting be selective? A case study from the Pyrenees

¿Es la caza del corzo selectiva? Un caso de estudio en el Pirineo

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Abstract

Trophy Hunting (TH) is thought to be the reason for the reduction in length and thickness of trophies as well as body size in several Bovidae species. In deer populations, changes have occurred in allele frequencies and in number of antler tips, possibly the result of the removal of males that showed the best trophies. To evaluate whether TH selection occurred in a roe deer population, we compared the antlers and body biometrics of bucks harvested (n=278, 2006-2014) through stalking with a ranger within Game Reserves in the Aragonese Pyrenees (Spain) and those of non-hunted bucks found dead in the same and surrounding areas (n=28, 2004-2014); the latter were necropsied. For the analyses, hunters were assigned to one of three categories: local, regional, or national, depending on the origin and access to the hunting permissions. The study assessed the selection perception and hunt difficulty among rangers (n=18) and hunters (n=209). Statistical analyses used non-parametric Mann-Whitney and Kruskal-Wallis tests. The results indicated that (i), in all biometrics except brow tines, hunted bucks were larger than the non-hunted ones, (ii) hunter typologies did not differ, and (iii) rangers and hunters did not differ in their perceptions of selection and difficulty. Our results suggest that, the roe deer hunt through stalking in the Game Reserves selected the best trophies, and the rangers were essential in that process. Furthermore, if the main objective of roe deer TH is to harvest the animals with larger antlers, this selection could have a long-term negative impact.
Keywords: *Capreolus capreolus*, Game Reserves, hunt perception, hunter typology, ranger, Trophy Hunt.

Resumen

La Caza de Trofeo podría ser la razón de la reducción en longitud y grosor de los trofeos de caza, así como del tamaño corporal en varias especies de Bóvidos. En poblaciones de cérvidos, ha habido cambios en las frecuencias alélicas y en el número de puntas, posiblemente debido a la eliminación de los machos con los mejores trofeos. Con el fin de evaluar la posible selectividad del trofeo en la caza del corzo hemos llevado a cabo una comparación de la biometría de los corzos cazados a rececho, con guarda acompañante, en las Reservas de Caza (RC) del Pirineo aragonés (n=278, 2006-2014) con respecto a los corzos encontrados muertos, por otras causas, en las zonas afectadas y sus alrededores (n=28, 2004-2014). Los ejemplares pertenecientes a esta segunda muestra fueron todos necropsiados. Para los análisis, los cazadores fueron divididos en tres categorías: locales, regionales y nacionales, dependiendo de su origen y acceso a los permisos de caza. También comparamos la percepción de la selección y la dificultad de la caza entre los guardas acompañantes (n=18) y los cazadores (n=209). Los análisis estadísticos utilizados fueron las pruebas no paramétricas de Mann-Whitney y Kruskal-Wallis. Los resultados indicaron que (i) en todos los datos biométricos, excepto en las contraluchaderas, los individuos cazados eran más grandes que los no cazados, (ii) las tipologías de cazadores no presentan diferencias significativas, y (iii) guardas y cazadores no muestran diferencias significativas en sus percepciones de selección y dificultad. Nuestros resultados sugieren que la caza del corzo en las RC selecciona los mejores trofeos y que el papel de los

guardas acompañantes es clave para la obtención de estos resultados. Además, si el principal objetivo de la caza de trofeo de corzo busca abatir individuos con cuernas más grandes, esta selección podría tener un impacto negativo a largo plazo.
Palabras Clave: *Capreolus capreolus*, Caza de Trofeo, guarda, percepción de la caza, Reservas de Caza, tipología de cazador.

Introduction

Historically, wildlife agencies have established hunting quotas that regulate how many and which individuals may be hunted, as a means of maintaining unbiased population structure and unintentionally creating a purpose in hunting behaviour (Mysterud 2011). Selective big-game hunting typically focuses on specific sex/age-classes, or on morphological traits. For example, trophy hunting (TH) in ungulates aims to cull animals with the largest horns (*Bovidae*) or antlers (*Cervidae*) (CIC 1977).

Traditionally, ungulate TH has focused on males with largest horns, antlers and body mass, while avoiding lactating females. Such an approach exerts selective pressure on adult males or fast-growing young males and limits their reproductive potential, because adult sex ratio becomes biased towards females (Ginsberg *et al.* 1994). Female-biased population structure, in turn may affect sexual selection and reduce male-male competition, thus allowing young males to enter reproduction (Mysterud 2014). Individuals of different age, however, differ in their reproductive potential, and larger males can produce larger offspring; therefore, TH can affect population growth depending on which males have been harvested (Mysterud 2014). In bighorn sheep, for example, TH increased the reproductive success of small males, as in the long-term the horn size decreased, which highlights the unsustainability of this practice (Coltman *et al.* 2003). TH may occur not only in highly dimorphic species, such as bighorn rams (*Ovis Canadensis* Shaw, 1804) in bovids, or on red deer (*Cervus elaphus* Linnaeus, 1758), but also on weakly dimorphic species such as the Alpine chamois (*Rupicapra r. rupicapra* Linnaeus, 1758) (Corlatti *et al.* 2017).

In recent decades, the impact of TH has become an important issue in wildlife management. So far, most research has focused on Bovidae (Mysterud 2014), and concern over the evolutionary consequences of TH, particularly in body mass and weaponry of males, has increased (Mysterud & Bischof 2010). For instance, TH is thought to be the reason for the reduction in the average length and the thickness of the horns of bighorn rams (Coltman *et al.* 2003). In Iberian wild goat (*Capra pyrenaica* Schinz, 1838), high densities and the removal of the largest males coincided with a reduction in horn length (Pérez *et al.*, 2011). In bighorn sheep, for example, TH selected certain individuals, which differed from the sheep killed by non-hunting-related factors (Pelletier *et al.* 2012). Research studies on the effects of TH on cervids are less abundant; besides the effects of TH on age and sex structure of populations and on individual phenotypes, in deer populations changes (Mysterud 2014). Furthermore, in deer population changes have occurred in the allele frequencies and in the number of antler tips, possibly the result of the removal of males that showed the "best" trophies (Hartl *et al.* 1991).

Hunters' preferences are influenced by knowledge, skills, and cultural background (Festa-Bianchet *et al.* 2014). For instance, preferences can differ depending on the origin of hunters. In Poland, foreign hunters selected roe deer *Capreolus capreolus* (Linnaeus, 1758) with largest body mass and antlers, while deer harvested by local hunters largely included young animals (Mysterud *et al.* 2006). In addition, habitat can play a major role, as in open habitats it is easier for hunters to select males that have large antlers and a similar body size than it is in forests, where the animal's silhouette often is incomplete and the harvested deer are smaller than average (Ramanzin & Sturaro 2014). This form of selection can have long-term consequences on the target populations, for example in roe deer (Mysterud 2014).

TH can cause females to disperse during the mating season because of the stress caused by the presence of high male-male competition for mates in a population that has few mature males and a lesser-developed population structure. The result is an increase in energetic costs for females and a female-biased sex ratio (Mysterud 2014). Other hunting practices; e.g., battues, are less selective than is TH, and the average size of the antlers of harvested red deer is smaller (Martínez *et al.* 2005).

In some cases large males are harvested when their trophy is largest, after they have been able to reproduce (Apollonio *et al.* 2010). In small populations, any human-induced changes in population structure can have significant effects; e.g., in France, the removal of a few individuals had a substantial effect on the population (Garel *et al.* 2007).

Pelletier *et al.* (2012) demonstrated that the temporal trend underestimated horn size in hunted bighorn sheep; therefore, using data from TH to identify trends can be erroneous because it is associated with a selective factor that does not reflect the overall population (Schoenebeck & Peterson 2014; this study). In addition, in bighorn sheep (Coltman *et al.* 2003), mouflon (*Ovis orientalis* Gmelin, 1774) (Garel *et al.* 2007), Iberian wild goat, and aoudad *Ammotragus lervia* (Pallas, 1777) (Pérez-González & Carranza 2001) the biometrics of hunted animals was skewed from that of the population because of the hunter's pursuit for a specific sex, age, and phenotypic trait such as large horns.

Pigeon *et al.* (2016) demonstrated that strong selection in TH reduced significantly the horn length of male bighorn sheep. The reduction in the biometrics related to hunting (length) and the persistence of those not related to the hunt (thickness) suggest that the same phenomenon has occurred.

Torres-Porras *et al.* (2009) showed that the compensatory culling of red deer that had small bodies and antlers were eliminated in comparison with commercial TH of the species. Martínez *et al.* (2005) demonstrated that red deer TH has a significant effect on the relationship between weight and age depending on the way the data was gathered. The aim of hunt (TH, meat hunt, or culling for conservation purposes) introduced bias.

The aim of this study is to evaluate hunters' selectivity for male roe deer by (i) comparing the biometrics of hunted males and those of males found dead from non-hunting-related causes, (ii) comparing hunters' typologies results, and (iii) investigate the opinions of rangers and hunters about the difficulty of the hunt and their selection capabilities or rangers and hunters.

Material and methods

Study area

The study area was four Game Reserves (GR) of the Aragonian Pyrenees (Spain) and surrounding areas (Fig. 1). Data on hunted roe deer were collected in the GR (1,210 km^2), and those on non-hunted roe deer found dead came from these GR and their

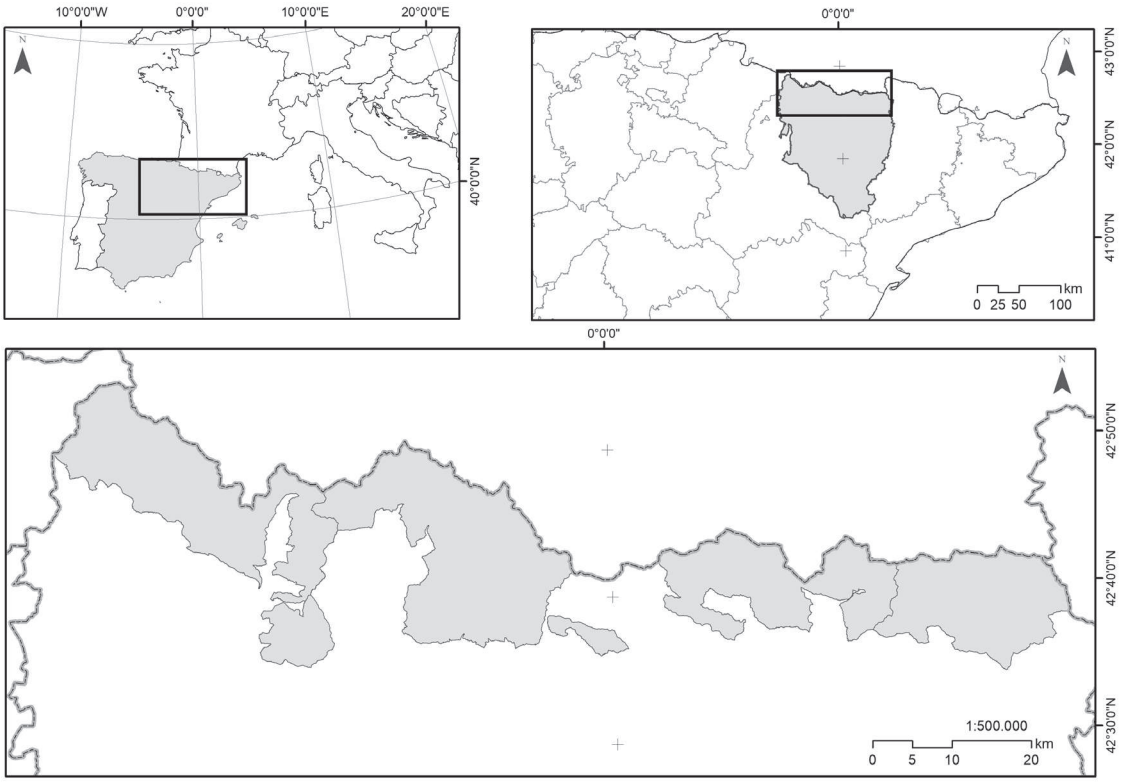

Figure 1. Study area in the Aragonian Pyrenees (Spain).

surrounding areas. GR are public hunting grounds, which are managed by regional governments (Pita-Fernández *et al.* 2012). Human density was approx. 6.6 inhabitants km^{-2} and the population had an aging profile (INE 2019). Tourism and livestock breeding are the main economic activities.

The elevation ranges between 600-3,404 m a.s.l. The mean annual temperature is 12 ºC, while the average temperature is 0 ºC at 3,000 m and 11 ºC at 600 m. In the western high valleys, where there is an Atlantic influence, annual precipitation is over 2,000 mm; in the east, annual precipitation is around 1,000 mm, and a significant proportion falls as snow. Biogeographically, the area is within the Eurosiberian region, and some areas are transitional to the Mediterranean. Subalpine pastures occurred between 1,600-2,000 m a.s.l., within areas dominated by Scots pine (*Pinus sylvestris*) and mountain pine (*Pinus uncinata*) forests.

In the montane habitats below 1,600 m, European beech (*Fagus sylvatica*) and silver fir (*Abies alba*) occur, while in the lowest forests, holm oak (*Quercus ilex*) and white oak (*Quercus humilis*) are present, along with pastures. Beside roe deer, other wild ungulates in the area (in order of density and distribution) include wild boar *Sus scrofa* Linnaeus, 1758, Pyrenean chamois *Rupicapra p. pyrenaica* Bonaparte, 1845, and red deer (Marco *et al.* 2011). Golden eagle *Aquila chrysaetos* Linnaeus, 1758 and red fox *Vulpes vulpes* (Linnaeus, 1758) are the main roe deer predators.

During the study period, roe deer density was 2.3 roe deer km^{-2} and the population was stable (λ= 1.0) (Herrero *et al.* 2013), unfenced, and not artificially fed.

There are three types of hunting permits, depending on the habitual residence of the hunter: villages belonging to the Game Reserve; the rest of the Aragon region and the rest of the Spanish territory. The three hunter categories (locals, regional, and national) paid similar quotas (90-200 €) to access the hunt. A ranger accompanied each hunter while hunting. Their role is to seek for roe deer before the hunters arrive; to take hunters to the hunting ground; to look for roe deer and select a trophy to be hunted.

Data analysis

To investigate the potential selective effect of hunting on roe deer phenotypes, we measured antler and body biometrics. Antler biometric included beam height (mm), brow tines (mm), back points (mm), coronet perimeter (mm), and apical beam separation (mm). Body biometrics included total length (cm), chest circumference (cm), metatarsal length (cm), and full body mass (kg, Pesola®) (Herrero *et al.* 2013). Antlers were measured using the old procedure of the Conseill International de la Chasse, which does not include the volume of antlers (CIC, 1977). The biometrics of the roe deer harvested (2006-2014) was recorded by rangers, while two of us (DFL and MCA) recorded those of the non-hunted ones (2004-2014) in the lab (Arnal *et al.* 2005). Only animals with complete antlers were considered. All roe deer found dead for other reasons rather than hunt had complete antlers, with brow tines and back points. In some cases back points were missing. Because of the health monitoring system in game wildlife established in the region, systematic necropsies were performed on dead animals to determine the cause of death.

To evaluate ranger and hunter perceptions of the selection capabilities, the difficulty, and the satisfaction of the hunt, a questionnaire was sent to the rangers and the hunters. Responses to the questions were based on a scale from 1 to 5: 1 non satisfied; 2 scarcely satisfied; 3 moderately satisfied; 4 satisfied and 5 fully satisfied.

The Kolmogorov-Smirnov test with the Lilliefors correction was used to check whether the different data sets, with more than 50 observations, fit a normal distribution or not, while the Shapiro-Wilk test was used in those with less than 50 data. The statistical significance of the differences between the groups in each of the variables studied was evaluated using Mann-Whitney U and Kruskal-Wallis tests.

Results

Between 2006 and 2014, 28 roe deer were found dead within the study area, 26 of them with traumatism, 14 were found near roads and two had been partially eaten after death and the cause of dead was undetermined.

Hunted (n=278; 90.9%) and non-hunted (n=28; 9.1%) roe deer differed significantly in all of the antler and body biometrics except brow tines (Table 1). The biometrics of harvested deer did not differ significantly among hunters with different hunting permissions typology (Table 2). Questionnaires were sent to 40 rangers and 102 hunters. Eighteen rangers (45%) and 50 (49%) hunters replied. The

responses of rangers and hunters did not differ significantly (Table 3).

Discussion

In our study population, hunted roe deer consistently showed larger biometric values than the non-hunted ones, while no selectivity was detected among hunter typologies.

Hunter's preferences based on culture, religion, ethics, knowledge, skill, and motivation can affect wildlife populations (Mysterud 2011). In our study, TH in Aragonian Game Reserves was highly selective because the best trophies and the largest animals were harvested, something which occurs in other deer populations (Schoenebeck & Peterson 2014).

Thus, in general, studies based on the biometric trend of selectively hunted ungulates can be inaccurate as a means of detecting changes in these characters. For that reason, research on the ecological evolution of wild populations must be based on samples that are representative of the populations and use the same sampling procedure. That said, the data obtained from TH trends can be

Table 1. Characteristics of Pyrenean roe deer antlers. Harvested in GR (2006-2014); found dead for other reasons (2004-2014); ns: non-significant; *<0.05; **<0.01; *** <0.001.

Variables	Source	n	Average	Standard deviation	Median	Coefficient of variation	Range	U Mann-Whitney p-value
Beams height (mm)	Hunted	273	197.9	25.5	200	13%	110-265	<0.001***
	Found dead	24	157.3	35.1	166	22%	73-215	
Top tines (mm)	Hunted	274	212.6	22.9	212.5	11%	100-262.5	<0.001***
	Found dead	28	177	47.6	183,8	27%	74-246.5	
Brow tines (mm)	Hunted	263	44.7	20.2	42.5	45%	8-160	0.087 ns
	Found dead	21	36.2	28.6	24.5	79%	2-86	
Back tines (mm)	Hunted	241	32,6	13.8	31	42%	7.5-110	0.002**
	Found dead	14	20.9	12.7	19	61%	4-46.5	
Coronet perimeter (mm)	Hunted	273	121	18.7	120	15%	50-190	<0.001***
	Found dead	28	102.3	26	101.5	25%	57-157.5	
Apical beam separation (mm)	Hunted	239	115.8	27.1	115	23%	35-220	<0.001***
	Found dead	24	81.9	21.9	83.5	27%	42-119	
Total length (cm)	Hunted	256	111.6	5	111	4%	95-126	0.034*
	Found dead	25	108.5	6.9	108	6%	96-121	
Chest circumference (cm)	Hunted	240	68.1	5	68	7%	54-85	<0.001***
	Found dead	25	61.1	5	60	8%	53.5-77	
Metatarsal (cm)	Hunted	248	28.6	4.1	29	14%	15-39	<0.001***
	Found dead	24	24.9	1.2	25	5%	22.5-27	
Whole weight (kg)	Hunted	245	23.5	2.5	23	11%	17-33	<0.001***
	Found dead	22	19.7	2.9	19.3	15%	14.3-27	

Table 2. Biometric characteristics of roe deer harvested as trophies in the Pyrenees (2006-2014) considering hunting permissions typology; ns: non-significant.

Variables	Local hunters (n)	Regional hunters (n)	National hunters (n)	Kruskal-Wallis p-value
Beams height (mm)	200.3 (95)	194.3 (90)	197.7 (54)	0.247 ns
Top tines (mm)	215.4 (95)	208.8 (90)	212.4 (55)	0.050 ns
Brow tines (mm)	45.6 (91)	43.6 (86)	43.2 (52)	0.643 ns
Back points (mm)	33.1 (86)	31.7 (77)	32.8 (45)	0.572 ns
Coronet perimeter (mm)	120.1 (94)	120.1 (90)	119.5 (55)	0.962 ns
Apical beam separation (mm)	115.8 (81)	115.5 (85)	114.4 (45)	0.967 ns
Length (cm)	111.8 (90)	111.7 (85)	111.5 (51)	0.999 ns
Chest circumference (cm)	67.2 (89)	68.4 (74)	69.3 (50)	0.101 ns
Metatarsal (cm)	28.3 (86)	28.4 (81)	29.1 (51)	0.514 ns
Whole weight (kg)	23.6 (83)	23.4 (82)	23.4 (50)	0.621 ns
Total hunters (n)	97	91	56	244

Table 3. Survey on the perception of the roe deer hunt in GR by rangers (n = 18) and hunters (n = 50); ns: non-significant.

Questions	Source	Mode	Average	U Mann-Whitney
Selection capacity	Rangers	4	4	0.101 ns
	Hunters	4	3.5	
Results match with expectations	Rangers	4	3.9	0.263 ns
	Hunters	5	3.3	
Hunter's satisfaction with hunt	Rangers	4	3.9	0.449 ns
	Hunters	5	4	
Hunter's satisfaction with trophy	Rangers	3	3.3	0.196 ns
	Hunters	3	2.9	
General satisfaction	Rangers	4	4	0.051 ns
	Hunters	5	4.4	
Difficulty	Rangers	5	4	0.561 ns
	Hunters	4	4	

useful depending on the intended use of the data and encourages researchers to test methods that identify bias (Martínez *et al.* 2005).

Mysterud *et al.* (2006) argued that foreign hunters selected roe deer that had the largest antlers, but local hunters did not, possibly because foreign hunters paid a higher price to access hunt than did local hunters, and they had some privileges such as hunting at the beginning of the hunting season. In addition, Rivrud *et al.* (2013) found that, in Hungary, foreign hunters accompanied by rangers selected larger and older trophies than did local hunters. TH was a privilege for foreign hunters and the political elite in the country. A change in the management approach made results more balanced (Rivrud *et al.* 2013). In our study, the lack of differences might have been because of an unbiased approach, because the hunting fees and the role played by rangers were similar among the three hunter categories. The demand for attendant rangers is highest among foreign hunters because their participation produces the best results in TH (Schmidt *et al.* 2007).

In the GR of the Aragonian Pyrenees, hunters and rangers found the roe deer TH equally difficult, a positive experience, and the hunters had a positive view of the selection abilities of the rangers. Putman (2005) indicated the difficulty of deciding quickly whether to shoot overlap among hunters, and rangers in the experience evaluation and the selection capacity of rangers.

Future research should focus on the impact of systematically harvesting the animals with larger antlers, which could have a long-term negative impact.

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