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INFLUENCE OF MANAGEMENT PRACTICES ON NEST SITE HABITAT SELECTION, BREEDING AND DIET OF THE COMMON BUZZARD *BUTEO BUTEO* IN TWO DIFFERENT AREAS OF SPAIN

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SUMMARY.—*Influence of management practices on nest site habitat selection, breeding and diet of the common buzzard* Buteo buteo *in two different areas of Spain.*
Aims: The density, nest spacing, breeding habitat selection, diet and productivity of two sedentary populations of common buzzards was studied for six to eight years in two different areas of Spain, in relation to landscape and anthropogenic factors.
Location: Bizkaia (Northern Spain) and Murcia (Southern Spain)
Methods: Two populations of common buzzard were studied, one from 1996-2003 in Bizkaia (Northern Spain, Eurosiberian region) and the other one from 1998-2003 in Murcia (Southeastern Spain, semiarid Mediterranean region). Breeding parameters and diet were obtained every year. Home range habitat preferences were examined by comparing habitat composition around 18 occupied sites and 17 non-occupied sites in both areas, using logistic regression and two-sample tests.
Results: The density was 45 territories per 100 km^2 in Bizkaia and 8 territories per 100 km^2 in Murcia. Productivity was similar in both areas at 1.72 and 2 fledged young per successful pair respectively. Diet was dominated by small-sized prey in Bizkaia and medium-sized prey in Murcia. More intensive timber management in Bizkaia caused buzzards to select mature pine forest, independently of the size of the forest patch. In contrast, timber management practices in Murcia result in continuous pine forests, where Common buzzards selected mature patches far from the forest edge. Moreover, buzzards appear to avoid sources of human disturbance in both areas.
Conclusions: Differences in habitat structure between the regions appear to drive differences in density. Moreover, prey diversity differed between regions probably partly as a response to timber management and this probably contributes to the observed differences in population structure. Common buzzards appear to respond to habitat alteration in a variety of ways, ranging from their choice of forest structural characteristics to the placement of the nest site.

Key words: Buteo buteo, common buzzard, diet, habitat selection, timber management.

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RESUMEN.—*Influencia de las prácticas de gestión en la selección del hábitat de nidificación, la reproducción y la dieta del busardo ratonero* Buteo buteo *en dos áreas diferentes de España.*
Objetivos: Durante ocho años se estudió la densidad, distribución de nidos, selección de hábitat de nidificación, producción y dieta de dos poblaciones sedentarias de busardos ratoneros de dos diferentes regiones biogeográficas de España, Eurosiberiana y Mesomediterranea, caracterizadas por situarse en zonas de una gran presión de la industria maderera. Los objetivos de este trabajo fueron establecer las relaciones entre los diferentes parámetros biológicos y las diferentes interacciones humanas de ambas zonas.
Localización: Bizkaia (Norte de España) y Murcia (Sur de España)
Metodos: Se estudiaron dos poblaciones de busardos ratoneros, una entre 1996 y 2003 en Bizkaia (región Eurosiberiana) y la otra entre 1998 y 2003 en Murcia (región Mediterránea Semiárida). Los parámetros reproductores y la dieta fueron obtenidos anualmente revisando los nidos. Las preferencias del hábitat de nidificación de los busardos ratoneros fueron analizadas comparando la composición del hábitat alrededor de 18 nidos ocupados y 17 lugares elegidos al azar, en ambas áreas.
Resultados: La densidad fue de 45 territorios por cada 100 km^2 en Bizkaia y 8 territorios por 100 km^2 en Murcia. El éxito reproductor fue parecido en las dos áreas, 1,72 y 2 volantones por pareja exitosa, respectivamente. La dieta estuvo dominada por presas de pequeño tamaño en Bizkaia y presas de medio tamaño en Murcia. La gestión maderera en Bizkaia, más agresiva, obligaba a los busardos ratoneros a elegir pinares maduros para anidar, independientemente de su tamaño, mientras que en Murcia, donde la gestión maderera es más suave y origina bosques más extensos y uniformes, los ratoneros seleccionaban parcelas maduras alejadas de los bordes del bosque. Además, los ratoneros evitaban la presión humana en ambas áreas.
Conclusiones: La estructura poblacional y el éxito reproductor en ambas provincias estuvieron básicamente relacionados con la dieta y el modo de caza oportunista de la especie, mientras que la gestión maderera parece ser el principal factor que regula la diversidad de presas y las limitaciones ecológicas del busardo ratonero. En conclusión, el busardo ratonero parece responder particularmente a las diversas alteraciones del hábitat, desde las características estructurales de los bosques hasta las individualidades del lugar de nidificación.
Palabras clave: Busardo ratonero, *Buteo buteo*, dieta, gestión maderera, selección del hábitat.

INTRODUCTION

The common buzzard *Buteo buteo* is one of the most abundant Spanish raptors (Balbas, 2003), occupying a wide range of different habitats although it prefers forested habitats interspersed with, or fragmented by, fields or clearings. Such a composition probably best suits its principal hunting method, wait-and-strike (Bijlsma, 1997). It is a non-specialised raptor that preys on a wide range of species (Spido and Selas, 1988; Mañosa and Cordero, 1992; Jedrzejewski *et al.*, 1994; Sergio *et al.*, 2002). The amount and availability of its main prey species strongly influences its breeding success (Holdsworth, 1971; Spido and Selas, 1988; Jedrzejewski *et al.*, 1994; Dare, 1995; Graham *et al.*, 1995; Penteriani and Faivre, 1997; Cesaroli and Penteriani, 1996; Vorisek, 2000; Sim *et al.*, 2001; Sergio *et al.*, 2002; Löhmus, 2003).

The main threat to the species has always been human persecution, which can produce high levels of adult mortality, abandonment of territories, loss of nests and, consequently, population declines (see Kostrzewa, 1989; Penteriani and Faivre, 1997). Moreover, pesticides caused a high population decrease over Europe in the 1950s and 1960s (Biljsma, 1997a). Nevertheless, during recent decades numbers have increased in many European countries, probably as a result of recovery from pesticide-induced depletion, combined with reduced persecution (Bijlsma, 1997a).

Despite its abundance and wide distribution, the breeding ecology and population trends of this species is virtually unknown in Spain. It is abundant and widely spread over the country, indicating that it is a versatile raptor, and although associated with forest can develop different strategies to live in different forest types (Diaz *et al.*, 1996). The abundance and breeding success of this species could be an important tool to indicate the health of the environment. Although Environmental Impact Assessment (EIA) is mandatory prior to habitat alteration in Spain, inappropriate species or ecological parameters have often been considered (Martínez *et al.*, 2003a).

In this paper, data is presented on density, nest spacing, breeding habitat selection, diet and productivity of two sedentary populations of common buzzards studied for eight years in two different areas of Spain, characterised by the high degree of timber management. Moreover, the interactions between the parameters in each area and between areas are analysed and compared considering the environmental factors.

MATERIAL AND METHODS

Study area

Two populations of common buzzard were studied, one from 1996 - 2003 in Bizkaia (Northern Spain, Eurosiberian Region) and the other one from 1998 - 2003 in Murcia (Southern Spain, Semiarid Mediterranean Region, Fig. 1). In Bizkaia, the study was conducted in a densely populated area of 40 km^2 near Bilbao. The climate is oceanic, with a mean annual rainfall of 1000 mm, and altitude ranged from 10 - 242 m a.s.l. This area lies in a valley oriented SE to NW. Several towns and farmhouses with a highly developed road network occupy the central part of the valley. Small grassfields and orchards between houses and open fields surround the landing roads of the Bilbao airport. Two lines of mountains, orientated NE to SW, lie either side of this central flat area. The mountains are covered by pine *Pinus radiata* and eucalyptus *Eucalyptus globulus* timber plantations, and patched by small fields and oak forest. Oaks *Quercus robur* dominate the native species which are around the edges of timber forests and in the boundaries between fields and orchards, although there are no patches higher than 0.5 ha. Rivers are bordered by only one line of trees, mainly alders *Alnus glutinosa* and ashes *Fraxinus excelsior*. There is intensive timber harvesting activity, the average forest rotation being 35 - 40 years.

The Murcia study area lies in a mountainous area in the centre of the region of Murcia (south-eastern Spain) and covers about 100 km^2, with elevations ranging from 550 to 1234 m a.s.l. The climate is Mediterranean with a mean annual rainfall of 400 mm. The landscape is characterised by mountain slopes covered by pine forests *Pinus halepensis* interspersed with traditional agroecosystems (cereals, vineyards, olive and almond groves). The study area lies within a Special Protection Area for birds (Sierras de Burete, Lavia and Cambrón; reference code ES0000267), which is included in

FIG. 1.—Study areas location. Bizkaia located in the north and Murcia in the south of Spain. *[Localización de las zonas de estudio. Bizkaia en el norte y Murcia en el sur de España.]*

the Natura 2000 Network, the system of protected areas of the European Union.

Location of territorial pairs and nests

Nesting areas of common buzzards were located every year from February to April by watching territorial displays and transfers of nest material, followed by intensive nest searches. Territorial pairs were defined as those that built nests, but not necessarily laid eggs. The nearest-neighbour distance was obtained from distances between nests or centroids, where a group of nests belonging to the same pair was found in different years. Nest coordinates were obtained with a GPS (accuracy of approximately 10 m) and distances were measured using a GIS (Arcview).

Parameters of breeding success

Nests were visited at least twice: (1) during the incubation period, in order to assess clutch size and (2) when the nestlings were between 15 and 30 days old. To minimise the risk of disturbance, readily accessible nests were visited during the incubation period. A final visit was made soon after fledging to those territories that raised at least one young successfully, to determine how many chicks actually fledged. Laying dates were calculated by subtracting 30 - 34 days from the hatching day which, in turn, was calculated by backdating nestlings aged from feather development (Biljsma, 1997b and own unpubl. data). Chicks were ringed and measured when they were 15 to 30 days old.

Prey identification

Prey remains found in the nest during each visit were identified assuming the minimum possible number of individuals per collection event (see Sergio *et al.*, 2002). Prey identification was carried out with a reference collection.

Environmental parameters

Selection was made of 20 variables related to land use, topography and human influence, which could be important to the species in the study areas (Table 1). The measurements of the nest and distances between the nest and the forest edge were taken with a metric tape. Following Sim *et al.* (2001), circular plots of 600 m radius were established around nest trees. Nest site habitat characteristics were analysed using a GIS from the Basque and the Murcia forest inventories. Nest maturity is expressed as the age of the forest plantation in Bizkaia, and as the diameter of trunks in Murcia. The density of trees in the nest plot is expressed as the average distance between trees in Bizkaia (1 = 1 - 2 m, 2 = 2 - 4 m, 3 = 4 - 5 m, 4 = 5 - 6 m, 5 > 6 m) and the number of trees within 10 m around the nest in Murcia.

Analytical methods

In order to avoid pseudoreplication in the habitat analyses, only the most used nest per territory was considered. An equal number of non-occupied locations were randomly chosen so as to have an equivalent relationship between both (Morrison *et al.*, 1998). Locations were not selected in non-suitable nesting habitat (cities, deforested areas and others). Random locations were a minimum 600 m away from the centre of occupied territories.

The degree of regularity of nest dispersion was estimated by means of the G-statistic (Brown, 1975), calculated as the ratio between the geometric and the arithmetic mean of the squared nearest neighbour distance (NND) between used nests. This ranges between 0 and 1, with values close to 1 (> 0.65) indicating a regular dispersion of the nests (Brown, 1975).

TABLE 1

Codes and definitions of independent variables and factors used in the analyses. (1) Variables selected in the PCA and used in the logistic regression of Bizkaia, and (2) in the logistic regression of Murcia.
[Códigos y definiciones de las variables independientes y los factores utilizados en los análisis. (1) Variables seleccionadas en el ACP y utilizadas en la regresión logística de Bizkaia, y (2) en el caso de Murcia.]

Variable Code *[Código de las variables]*	Definition *[Definición]*
Variables related to availability of hunting areas *[Variables relacionadas con la disponibilidad de zones de caza]*	
ARAB (2)	Area of arable land (m^2) *[Superficie de tierra de cultivo]*
GRAS (1)	Area of grasslands (m^2) *[Superficie de prados]*
SHRUB (1)	Area of shrubs, brambles, etc. less than 3 m. high (m^2) *[Superficie de matorrales menores de 3 m. de alto]*
HAIND (2)	Habitat diversity index *[Índice de diversidad de hábitats]*
BOUND (2)	Lengths of habitat boundaries (m) *[Longitud de ecotonos]*
Variables related to suitability of nest sites *[Variables relacionadas con los lugares de nidificación]*	
FOREST (2)	Area of forests (m^2) *[Superficie forestal]*
PINE (1)	Area of pine timber plantation (m^2) *[Superficie de cultivos de pinares madereros]*
EUCAL	Area of eucalyptus timber plantation (m^2) *[Superficie de cultivos de eucaliptos madereros]*
DECID	Area of mature deciduous woodland (m^2) *[Superficie de bosque caducifólio]*
EDGE (2)	Distance from the nest to the forest edge, when open lands or shrub appear. (m) *[Distancia del nido al borde del bosque, donde aparecen prados o matorrales]*
OPENL (1)	Distance from the nest to the nearest open land (m) *[Distancia del nido a la superficie abierta más cercana]*
NESTF	Size of the nest forest (m^2) *[Superficie del bosque de nidificación]*
TREED	Average tree density in the nest forest *[Densidad media de árboles en el bosque de nidificación]*
NESTM (2)	Maturity of the nest forest/DBH (cm) *[Madurez del bosque de nidificación/DBH]*
Variables related to disturbance *[Variables relacionadas con fuentes de molestias]*	
ROAD (1,2)	Distance from the nest to the nearest road (m) *[Distancia del nido a la carretera más cercana]*
BUIL (1,2)	Distance from the nest to the nearest building (m) *[Distancia del nido a la casa más cercana]*
NBUIL (1,2)	Number of buildings [Edificios]
Variables related to topographic conditions *[Variables relacionadas con condiciones orográficas]*	
SLOPE	Slope aspect *[Orientación]*

TABLE 1 (CONTINUACIÓN)

Variable Code *[Código de las variables]*	Definition *[Definición]*
RELIEF (1,2)	Relief index. Number of contours (25 m intervals) that cut the circle around the nest. *[Índice de relieve. Número de curvas de nivel (25 m) que cortan la circunferencia que rodea al nido]*
Variables related to population density and distribution *[Variables relacionadas la densidad y distribución de la población]*	
NND	Nearest Neighbour Distance (m) *[Distancia al vecino más próximo]*

A Principal Components Analysis (PCA) was performed with the habitat variables in order to reject covariables (Kelt *et al.*, 1994; Morrison *et al.*, 1998). Four components of the PCA with eigenvalues greater than 1.0 were retained for ecological evaluation (Kelt *et al.*, 1994; Morrison *et al.*, 1998). Factors obtained automatically in the analysis from the components with eigenvalues greater than 1.0 were then tested against dependent variable using the Spearman correlation test (Andrews and Carroll, 2001; Andrews *et al.*, 2002; Zabala *et al.*, 2003). Only the first component was statistically correlated in both cases ($P < 0.01$). The model extracted strong weightings variables (values higher than 0.3) of the PCA 1, eight for Bizkaia and 10 for Murcia (Tables 1 and 2). Logistic regression models were constructed using the forward Wald Stepwise method with the variables selected by the PCA in order to determine variables driving the habitat selection. The binary response variable "nest or random locations" of common buzzards was used as the dependent variable. The significance of the model was tested with the Wald test, and only those variables significant at $P < 0.05$ were included in the models (Hinsley *et al.*, 1995; Austin *et al.*, 1996; Morrison *et al.*, 1998).

Moreover, analysis was carried out of four variables (maturity of the nest forest, average tree density, size of nest forest, distance from the nest and the forest edge) of the nest sites using bivariate analyses. Variables were tested for normality using Kolmogorov-Smironov test and then values for nest sites and random plots were compared using the Mann-Whitney (nonparametric) or Student test (parametric). Slope aspect and nesting tree selection were analysed using chi-square tests. The SPSS 11.0 package was used to develop statistical analyses.

RESULTS

In Bizkaia, 18 territories of common buzzards were found, the number of breeding pairs varying annually between 16 and 18. The spatial pattern of dispersion was regular in Bizkaia during the study period (Table 3), although buzzards frequently used different nests within their territory between years. The average period of occupation for one nest was 1.73 years (SD = 0.60, range = 1 - 5, n = 70 nest). Most of the movements were short distance movements (50 - 200 m) other than three, which were in response to the timber extraction, when the woods where the buzzards bred were cut down.

The Murcia population varied between six and nine territories. The distribution pattern and the distances between neighbouring nests varied notably between years (Table 3).

The nests were found at an average height of 14.5 m (SD = 4.47, range = 9 - 24.5, n = 34) in Bizkaia and 9.0 m (SD = 1.57, range = 5.8

TABLE 2

Loading factors of the principal component analysis (PCA) after Varimax rotation performed with the habitat variables for Bizkaia and Murcia.
[Factores de carga del análisis de componentes principales (ACP) tras efectuar la rotación Varimax realizado con las variables de hábitat para el caso de Bizkaia y Murcia.]

	PCA Bizkaia				PCA Murcia			
	PCA1	PCA2	PCA3	PCA4	PCA1	PCA2	PCA3	PCA4
Eigenvalue *[Autovalor]*	6.671	2.093	1.688	1.164	5.630	1.902	1.586	1.011
Variance (%) *[Varianza (%)]*	39.240	12.313	9.927	6.844	43.306	14.634	12.204	7.778
SVariance (%) *[SVarianza (%)]*	39.240	51.553	61.479	68.324	43.306	57.940	70.143	77.922
ARAB					-0.906			
GRAS	-0.827							
URBAN		-0.632	-0.461	0.321				
SHRUB	0.791	0.317					0.802	0.405
HAIND		0.796			-0.805			
BOUND		0.879			-0.859			
FOREST				0.442	0.870		-0.336	
PINE	0.448		0.439	-0.353				
EUCAL		0.816						
DECID			0.604					
EDGE			0.777		0.710	0.437		
OPENL	0.751		0.324					
TREED		-0.494	-0.569				-0.544	0.685
NESTM				0.790	0.383	-0.585	0.513	
ROAD	0.687		0.480		0.455	0.661		
BUIL	0.766		0.523		0.817			
NBUIL	-0.453	-0.583	-0.444		-0.662			-0.408
RELIEF	0.693	0.575			0.712		0.343	

- 11.8, $n = 18$) in Murcia. Most of them were built on one or more branches against the trunk, but sometimes the nest was located within the first (16.2 %), second (12.9 %) and, in one instance each, three and five meters from the trunk in Bizkaia.

Most of the nests in Bizkaia (56) were located in pines, while four nests were in eucalyptus and only one was in an oak. There was a statistically significant association between the tree selected for nesting and tree species availability ($\chi^2_2 = 100.72$, $P < 0.001$). Pines were positively selected while eucalyptuses were negatively selected. Likewise, all common buzzard nests in Murcia (19) were invariably located in *Pinus halepensis*, which is the main tree species in the study area.

There were no differences in the maturity of the nest forest when compared with randomly selected stands in Bizkaia, although no nest

TABLE 3

Density and nest dispersion data of common buzzards in Bizkaia (1996-2003) and Murcia (1998-2003).
[Densidad y datos de dispersión de los busardos ratoneros en Bizkaia (1996-2003) y Murcia (1998-2003).]

	Bizkaia	Murcia
Number of territorial pairs *[Número de parejas territoriales]*	18 (stable)	6 - 9
Density *[Densidad]*	0.45 terr./km^2	0.06 – 0.09 terr./km^2
Mean of NND *[Media de NND]*	1254 m	1793 – 2453 m
G-statistic *[Estadístico G]*	0.845	Between 2000-2003: 0.685-0.888 In 1998: 0.613 In 1999: 0.540
Nest dispersion *[Dispersión de nidos]*	Regular	Regular between 2000 and 2003. Non-regular in 1998 and 1999

TABLE 4

Nesting site characteristics of common buzzards in Bizkaia and Murcia. Comparisons are made at 19 occupied and 18 randomly selected forests using t-test or Mann-Whitney test in each area. (* P < 0.05; ** P < 0.01; *** P < 0.001). For definition of variables see Table 1.
[Características de los lugares de nidificación de los busardos ratoneros en Bizkaia y Murcia. Las comparaciones son realizadas considerando 19 territorios ocupados y 18 bosques seleccionados al azar en cada zona, aplicando la prueba de la t de Student o de Mann-Whitney según proceda.]

	Bizkaia			Murcia		
	Mean *[Media]*	SD *[DT]*	Statistic *[Estadístico]*	Mean	SD	Statistic
NESTM	29.17 ages *[años]*	6.91	t = -1.588	57.74 cm	22.74	t = -2.825**
TREED	3.05	0.80	U = 87.5**	20.10	13.0	t = -0.224
NESTF	11.33 ha	24.96	U = 73.3**			
EDGE	33.67	29.81	t = -0.308	660	360	t = -2.056*

could be found in pines younger than fifteen years (Table 4). Nests found in eucalyptus were in trees aged more than forty years (more than 80 cm of diameter). In contrast, common buzzard nests were located in more mature stands in Murcia than recorded for random sites (Table 4).

In Bizkaia, buzzards selected woods where trees were between three and five meters apart and no nests were found in dense forests (timber plantations younger than 15 years) or open forest (parks and highly managed woods). Likewise, they rejected small patches of trees and the narrow line of trees along rivers. The average forest size where common buzzard nests occurred ranged between 0.5 and 100 Ha. The variable "distance between the nest and the forest edge" was not selected at all by common buzzard, and nests were between 2 and 100 m away from the forest edge (Table 4).

TABLE 5

Aspect of the nesting forest. Table shows the utilisation frequency (%) of the different aspects. Preferences were analysed using Chi square test (* P < 0.05; ** P < 0.01).
[Orientación del bosque de nidificación. La tabla muestra la frecuencia de uso (%) de cada una de las orientaciones. Las preferencias fueron analizadas utilizando el test de la Chi cuadrado]

	N	NE	E	SE	S	SW	W	NW	c2	*n*
Bizkaia	16.7	33.3	16.7	16.7	10	0	6	0	20.13**	30
Murcia	42	31.58	0	0	15.79	0	5.3	5.3	27.74**	19

TABLE 6

Logistic regression models for the nests and random locations of common buzzard in both Bizkaia and Murcia. For Bizcaia, the 78.8 % of the cases were correctly classified (Cox and Snell $R^2 = 0.355$; Nagelkerke $R^2 = 0.473$). For Murcia, the 84.2 % of the cases were correctly classified (Cox and Snell $R^2 = 0.518$; Nagelkerke $R^2 = 0.690$).
[Modelo de regresión logística de la presencia o ausencia de nidos de busardo ratonero en Bizkaia y Murcia. En Bizkaia, el 79.8 % de los casos estuvieron correctamente clasificados. En Murcia, el 84.2 % de los casos estuvieron correctamente clasificados.]

	B	TE	Wald	df	*P*	Exp (B)
Bizcaia						
Constant *[Constante]*	-2.512	0.868	8.378	1	0.004	0.081
Distance to the nearest road *[Distancia a la carretera más cercana]*	0.018	0.006	9.496	1	0.002	1.018
Murcia						
Constant *[Constante]*	-8.287	2.551	10.553	1	0.001	0.000
Relief indexes *[Índice de relieve]*	0.177	0.052	11.473	1	0.001	1.194

In Murcia the pine forest was almost continuous, with just a few isolated areas not used by common buzzards, so differences in the forest size between occupied and random stands could not be analysed. There were no significant differences in tree density between occupied and randomly selected stands (Table 4). Nevertheless, common buzzards preferred trees located far away from the edge of the forest, distances ranging between 80 and 1650 m. (Table 4).

Analysis of nest forest aspect in both areas showed that most of the nesting forests had a northeast aspect (Table 5).

The Logistic Regression models relating nest sites to habitat retained only the distance from the nest to the nearest road for the Bizkaia area and relief index in the nest plot in Murcia (Table 6).

Common buzzards started to lay 20 days earlier in Bizkaia than in Murcia (Student test, $t = 3.89$, $P < 0.001$; Table 7). The number of eggs and fledglings produced per successful pair was slightly higher in Murcia than Bizkaia but this difference was not significant (Student test, $t = 2.01$, $P = 0.10$, $n = 6$ years).

There were no significant differences in the productivity between years either in Bizkaia

TABLE 7

Breeding parameters of the common buzzard in Bizkaia (1996 - 2003) and Murcia (1998 - 2003).
[Parámetros reproductores del busardo ratonero en Bizkaia (1996 - 2003) y Murcia (1998 - 2003)]

	Bizkaia	Murcia
Mean laying date *[Fecha media de puesta]*	28 March	16 April
Laying date range *[Rango de la fecha de puesta]*	3 March - 16 April (n = 31)	19 March - 21 May (n = 21)
Mean clutch size *[Tamaño de puesta medio]*	2.00 (SD = 0.69, range 1 - 3, n = 35)	2.31 (SD = 1.00, range 1 - 4, n = 19)
Mean number of fledglings / successful pair *[Promedio de pollos volantones por pareja exitosa]*	1.72 (SD = 0.69, range 1 - 3, n = 64)	2.00 (SD = 0.15, range 1 - 3, n = 25)

(Kruskal-Wallis test, H = 13, df = 7, P = 0.072, n = 64) or in Murcia (Kruskal-Wallis test, H = 6.23, df = 5, P = 0.28, n = 25). Only one monitored nest failed in Bizkaia and two in Murcia.

Common buzzard fed their young mainly with rodents (voles and rats) and reptiles (snakes) in Bizkaia, whereas they brought mainly medium-sized birds and reptiles to the nest in Murcia, occasionally capturing rabbits (see Table 8).

DISCUSSION

The density in the two regions (45 territories against 8 territories per 100 km^2) was as wide as between any other two areas within the entire European range. The density found in Bizkaia was similar to the highest densities recorded in Britain, France, Poland and Germany (Dare, 1961; Jedrzejewski *et al.*, 1994; Hubert, 1993; Kostrzewa, 1996; Goszcynski, 1997), although higher densities have been found (*e.g.* 78 territories / 100 km^2 in the West Midlands of England; Sim *et al.*, 2001). The density and nearest neighbour distances found in Murcia were rather similar to those found in mountainous areas of Italy, Austria, Scotland and some parts of Germany (Kostrzewa and Kostrzewa, 1991; Dvorak *et al.*, 1993; Graham *et al.*, 1995; Penteriani and Faivre, 1997).

Habitat structure appears to drive the density and population differences between areas. Habitat conditions in the study area of Bizkaia, where forests are abundant, although patchily distributed, and where meadows, grasslands and orchards are frequent, favour common buzzards, although human density and timber harvesting reduces the quality of this habitat. Similarly, common buzzards favour wide forests surrounded by dry-farmed crops in Murcia, where the habitat conditions appear adequate for the species. In a non-exclusive way, competition with other raptors may also influence the abundance and distribution of common buzzards. In Bizkaia there were no raptor species able to compete with common buzzard, while in Murcia there were 21 - 29 booted eagle *Hieraaetus pennatus* and three northern goshawk *Accipiter gentilis* territories and frequent aggressive interactions between the three species have been recorded (Kostrzewa, 1991; Sergio and Boto, 1999; Martínez, 2002; Pagán *et al.*, 2004). The lack of competition in Bizkaia may be consequence of intensive timber management and high human density preventing more sensitive species from becoming established (see Zuberogoitia and Torres, 1997).

TABLE 8

Prey items found in the common buzzard nests of Bizkaia and Murcia.
[Presas encontradas en los nidos de busardo ratonero de Bizkaia y Murcia.]

	Bizkaia		Murcia	
	n	%	*n*	%
Reptiles Scales appeared abundantly in all the nests.				
[Reptiles] *[Las escamas aparecieron de forma abundate en todos los nidos]*				
Anguis fragilis	6	3.8		
Coronella austriaca	6	3.8		
Elaphe scalaris			3	1.8
Natrix maura	1	0.6		
Natrix natrix	1	0.6		
Snakes ind.				
[Culebras ind.]	30	19.0		
Lacerta lepida			55	32.9
Lacerta bilineata	1	0.6		
Psammodromus algirus			2	1.2
Lizards ind.				
[Lagartijas ind.]	3	1.9		
Total (%)		30.4		35.9
Amphibious				
[Anfibios]				
Bufo bufo			2	1.2
Total (%)				1.2
Mammals Hairs appeared abundantly in all the nests				
[Mamíferos] *[se localizaron abundantes muestras de pelos en todos los nidos]*				
Apodemus sylvaticus	5	3.2		
Arvicola terrestris	1	0.6		
Crocidura russula	8	5.1	1	0.6
Lepus granatensis			1	0.6
Microtus agrestis	26	16.5		
Microtus duodecimcostatus			1	0.6
Oryctolagus cuniculus			28	16.8
Rattus norvegicus	14	8.9	2	1.2
Sciurus vulgaris	2	1.3	4	2.4
Talpa europaea	11	7.0		
Total (%)		42.4		38.3
Birds				
[Aves]				
Alectoris rufa			9	5.4
Anthus trivialis	1	0.6		

TABLE 8

	Bizkaia		Murcia	
	n	%	*n*	%
Carduelis carduelis	1	0.6		
Columba livia			8	4.8
Columba palumbus			1	0.6
Coturnix coturnix	1	0.6		
Cuculus canorus	2	1.3		
Dendrocopos major	1	0.6		
Fringilla coelebs	1	0.6		
Galerida cristata			1	0.6
Gallus domesticus	1	0.6		
Garrulus glandarius	1	0.6	12	7.2
Jynx torquilla	3	1.9		
Parus major	2	1.3		
Passer domesticus	7	4.4		
Picus viridis			4	2.4
Streptopelia turtur			1	0.6
Sylvia atricapilla	3	1.9		
Turdus merula	19	12.0		
Paserines indet. *[Paseriformes ind.]*			3	1.8
Medium size bird indet. *[Aves de tamaño medio ind.]*			25	15.0
Total (%)		27.2	64	38.3
Invertebrates *[Invertebrados]*				
Beatles indet. *[Escarabajos ind.]*			4	2.4
Total items *[Presas totales]*	158		167	

Common buzzards in Bizkaia favoured pines and although there were other types of tree, they were rarely used. Likewise, common buzzards in Murcia bred only in pines. These patterns differ from other areas where common buzzards use more tree species (Jedrzejewski *et al.*, 1988; Hubert, 1992; Cerasoli and Penteriani, 1996; Sergio *et al.*, 2002). In Bizkaia, the availability of tree species was influenced by the high level of timber harvesting, with the more natural forest restricted to small patches

The average height of the nests was 14.5 m, in the upper 3/4 of the tree, which means that nests can only be constructed in the oldest trees. In Murcia, common buzzards selected mature trees for nest building at an average height of 9 m. A similar observation was made by Hubert (1993), who found that common buzzards did not breed in trees that were less than 14 m height, and most of the nests were in trees wider than 40 cm dbh, although other studies pointed to lower values (Jedrzejewski *et al.*, 1994), suggesting that this species can adapt its requirements to the available landscape features.

Common buzzards selected mature forests in both areas, although it seems more evident in Murcia. Most pairs selected the nest sites according to forest maturity. Moreover, the "forest area" variable was selected in Bizkaia, where there were no extensive forests and they were highly fragmented. There were no nests in small patches, in the forests along rivers or in isolated trees. Close and dense forests were never selected. In Murcia forest are extensive and less heterogeneous, and buzzards breed in the only available forest type. These differences in habitat may well explain some of the differences in the density of buzzards between the two regions. In fact, Austin *et al.* (1996) and Löhmus (2003) found habitat heterogeneity to be a determinant factor in common buzzards distribution. The first authors showed that buzzards were more abundant in patchy forest mixed with fields than in large and homogeneous forests, and Löhmus found that in poor vole years buzzards were more productive in heterogeneous landscapes and vice versa.

In Bizkaia, trees may give shelter from the prevailing NW winds by selecting the NE facing slopes, where increased sun exposure may reduce heat loss in the incubating female and nestlings. In contrast, in Murcia, selection of shady north and north-east aspects may avoid the excessive heat of the sun in spring (see Cerasoli and Penteriani, 1996; Penteriani and Faivre, 1997).

The logistic regression model suggested that human interference could constrain the distribution of territories. Kostrzewa (1989) and Penteriani and Faivre (1997) obtained similar results. Whereas in Bizkaia birds nested far from roads, in Murcia they occupied rugged areas that may be less accessible. Poor accessibility for people to the nest has been shown to partially explain the distribution of the eagle owl *Bubo bubo* in a neighbouring study area (Martínez *et al.*, 2003b).

These results suggest that in Spain, common buzzard is not a habitat specialist in the way that other tree-nesting, forest dependent raptors are (*e.g.* northern goshawk in Penteriani *et al.*, 2001). Consequently, apart from landscape heterogeneity, habitat differences between Bizkaia and Murcia would not fully explain the territory occupation pattern or the differences in breeding density found in this study. The diet, however, could account for the unexplained variability between areas.

The breeding success was more or less similar in the two areas, clutch size and fledgling productivity being very low in both. This study shows that both populations used similar prey types, although with differences in the size of prey taken. In Bizkaia small animals (voles, shrews, rats, lizards, small snakes and passerines) were chiefly taken, while in Murcia larger species, mainly lizards, medium sized birds and rabbits were taken. This size difference could explain the small differences in the breeding success between Bizkaia and Murcia. Other studies have shown that the density and the number of fledglings increase with rabbit availability (Holdsworth, 1971; Newton, 1979; Spido and Selas, 1988; Jedrzejewski *et al.*, 1994; Dare, 1995; Graham *et al.*, 1995; Penteriani and Faivre, 1997; Cerasoli and Penteriani, 1996; Sim *et al.*, 2001; Sergio *et al.*, 2002). Although common buzzards in Murcia preyed on rabbits, the abundance of this rodent in the study area is too low to have a positive effect on breeding performance. In fact, other studies carried out in neighbouring areas where the rabbits are abundant showed higher breeding values (3.16 fledglings / successful pair; Sanchez-Zapata *et al.*, 1995).

In Bizkaia, common buzzard density and breeding success may be relatively stable because of the availability of a relative wide variety of species. When voles are scarce, buzzards may hunt more reptiles, birds and other alternative prey. This may explain why the population was stable during the study period, yielding slightly lower breeding rates and with no differences in the breeding success between years. This hypothesis would also explain why the clutch size is kept low, larger clutches being associated with areas where the prey population fluctuates highly or those where rabbits are abundant (see Newton, 1979; Cramp, 1985; Spido and Selas, 1988; Swann and Etheridge, 1995; Austin and Houston, 1997; Sim *et al.*, 2001). In the case of Murcia, although rabbits were present in the diet of buzzards, several changes were detected in their populations and there were other raptor and owl species feeding on rabbits. These factors and those explained by habitat selection would induce low population densities in common buzzards and differences in their distribution between years. However, breeding success did not change, again due to the opportunistic hunting style of the species.

It is important to consider that the prey species community is also a function of habitat. In Bizkaia, where timber policies are aggressive, the prey species community is made up by those generalist species able to adapt to a highly changing environment. In Murcia, the species must adapt to a continuous forest habitat, although the more stable habitat leads to more stable prey communities than in the case of Bizkaia.

In conclusion, common buzzards as well as their prey species appear to respond to habitat alterations in a variety of ways, including habitat use and nest site selection. Our results suggest that even a generalist predator such as the common buzzard can be heavily influenced by management practices.

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