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HABITAT USE BY A REINTRODUCED POPULATION OF BEARDED VULTURES (*GYPAETUS BARBATUS*) IN THE ITALIAN ALPS

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ABSTRACT.—Following the reintroduction of the Bearded Vulture (*Gypaetus barbatus*) in the western Alps in 1987, the species reappeared in the Gran Paradiso National Park, Italy, where it had not been recorded since 1930. We analysed 1157 sighting records collected inside the park borders from 1989 to 2007. The number of sightings per year was not correlated with the number of captive-bred individuals released during the same year in the western Alps but was positively correlated with the number released one year prior and two years prior. Bearded Vultures were recorded mainly at higher altitudes during warmer months, and at lower altitudes when the terrain was mostly covered by snow, as were the two most abundant ungulates of the park, the alpine ibex (*Capra ibex*) and the alpine chamois (*Rupicapra rupicapra*), whose carcasses were primary food sources for vultures. Three habitats were used with a frequency significantly higher than expected based on availability: vegetated cliffs and screes, forest-scrub mosaic, and agriculture. Bare rocks and deciduous forests were used less frequently than expected, and other habitats were used in the same proportion as expected, including alpine grassland, coniferous forests, and alpine heaths and scrubs.

KEY WORDS: *Bearded Vulture*; Gypaetus barbatus; *Alps*; *habitat use*; *Italy*; *reintroduction*.

USO DEL HÁBITAT POR UNA POBLACIÓN REINTRODUCIDA DE *GYPAETUS BARBATUS* EN LOS ALPES ITALIANOS

RESUMEN.—Después de la reintroducción de *Gypaetus barbatus* en los Alpes del oeste en 1987, esta especie reapareció en el parque nacional Gran Paradiso, Italia, donde no se había registrado desde 1930. Analizamos 1157 registros de avistamientos recolectados dentro del parque entre 1989 y 2007. El número de avistamientos en cada año no se correlacionó con el número de individuos criados en cautiverio que fueron liberados en los mismos años en los Alpes occidentales, pero sí se relacionó positivamente con el número de individuos liberados un año y dos años antes. Los buitres fueron registrados principalmente a altitudes mayores durante los meses más cálidos y a altitudes menores cuando el suelo estaba casi totalmente cubierto por nieve, periodo durante el cual también se registraron las dos especies de ungulados más abundantes del parque (*Capra ibex* y *Rupicapra rupicapra*), cuyos cadáveres fueron la principal fuente de alimento para los buitres. Tres hábitats fueron usados con una frecuencia significativamente mayor de la esperada por su disponibilidad: barrancos con vegetación y pedregales, mosaicos de bosque y arbustales y áreas dedicadas a la agricultura. Las áreas con rocas desnudas y los bosques caducifolios fueron usados con menor frecuencia de lo esperado, y otros hábitats, como pastizales alpinos, bosques de coníferas y arbustales alpinos bajos, fueron usados en la proporción esperada.

[Traducción del equipo editorial]

The establishment of new populations of a threatened species following reintroduction is not always the outcome of the usually long and expensive reintroduction program. Some reintroductions are costly and may divert funds from other conservation issues. It is, therefore, essential to evaluate whether

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results meet conservation objectives. In a review of reestablishment programs for 198 species of birds and mammals, Griffith et al. (1989) reported that programs with certain features were more likely to produce positive results. For example, releases had greater success if conducted closer to the core of the historic range (78%) compared to at the periphery (48%); in excellent habitat (84%) rather than in poor habitat (38%); for herbivores (77%) rather than for carnivores (48%); with wild-caught (75%) vs. captive-bred animals (38%); and for game species (86%) compared to threatened and sensitive species (44%). Other factors, such as geographic position of released animals in relation to the former range and habitat suitability may also be considered. Historical distribution may be assessed by reviewing publications, unpublished reports, museum collections (e.g., Guidali et al. 1990, Mingozzi and Estève 1997). Habitat suitability is usually poorly documented and may not always be inferred by comparison with surviving populations (Margalida et al. 2008). As indicated by Hirzel et al. (2004), reintroduced species provide a valuable opportunity to test species' ecological requirements.

The Bearded Vulture (*Gypaetus barbatus*) was reintroduced in the Alps starting in 1986 with the purpose of reestablishing the local population, which became extinct during the first three decades of the twentieth century (Mingozzi and Estève 1997). Before 2006, 144 captive-born individuals were released in the wild across the Alps. In the western Alps, 39 vultures were released in Haute Savoie (France) starting in 1987, and 29 were released in Argentera Natural Park (Italy)/Mercantour Natural Park (France) starting in 1993. From 1997 to 2006, newly established pairs produced 33 wild-born fledglings (Zink et al. 2007). In this paper we analyse 20 years of Bearded Vulture observations within the Gran Paradiso National Park, in order to obtain information on habitat use and selection by nonbreeding Bearded Vultures inhabiting this pristine and well studied alpine area, where the last two wild individuals in the Alps were last observed between 1924 and 1930 (Mingozzi and Estève 1997).

METHODS

Study Area. The Gran Paradiso National Park (GPNP hereafter) covered a surface of 720 km² in the northwestern Italian Alps, with an altitude ranging from 700 to 4061 m asl. Most of the area was covered by alpine habitats such as meadows, rocks, and glaciers; forests covered less than 20% and human activities were concentrated only in few villages in the lower portions of the main valleys. Tree line, or the upper altitude where trees grow, was located at around 2000 m. As Bearded Vultures feed mainly on carcasses, the availability of dead, large mammals is essential for their sustenance. The GPNP hosts large populations of alpine ibex (*Capra ibex*), and of alpine chamois (*Rupicapra rupicapra*). Other large mammals which may contribute to the Bearded Vulture diet are the roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*), and alpine marmot (*Marmota marmota*). Dead animals were made available mostly through winter starvation of ibex and chamois and, in smaller quantities, by avalanche casualties and, starting in 2006, predation by wolves (*Canis lupus*). Domestic livestock were also present inside the park during summer months and some of them die because of disease or wolf predation, but their carcasses are removed by shepherds because of sanitary regulations, or in order to preserve evidence of wolf predation for compensation by park authorities. In this park, carcass removal does not appear to be a conservation problem for scavengers, as it may be elsewhere (Donázar et al. 2009), due to the abundance of wild mammals.

Records of Bearded Vulture Sightings. Sightings of Bearded Vultures in the GPNP were recorded starting in 1989, two years after the release of the first captive-born Bearded Vulture in the western Alps, and continuing until July 2007. Observations were made primarily by park wardens trained to distinguish among age classes of Bearded Vulture. The territory was explored during routine patrolling of the protected area, which was carried out by foot throughout the year, an achievement which was made possible by the existence of a dense network of paths and the presence of many shelters, even at higher altitudes.

Every observed individual was reported on field data sheets; the location of the first sighting, the altitude of flying birds, behavior, identity if marked, and age class were also recorded. The exact position was marked in a detailed map or, in more recent years, the GPS position was taken and corrected for flying height. Most released individuals could only be identified through visual marks such as decolored feathers, which are lost after molting; however, starting in 2004 some individuals were provided with satellite tags (Hegglin 2007).

Records of Sightings of Alpine Ibexes and Alpine Chamois. Alpine ibexes and alpine chamois were observed by park wardens during routine patrolling

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from 1 January 2003 to 10 December 2005, and the position of each individual was mapped and later inserted in a GIS-based database. Furthermore, the distribution of marked female alpine ibexes and male alpine chamois (the latter categorized as either sedentary/territorial individuals or wandering individuals) was described by researchers studying individuals radio-tracked inside the park during the period of interest (Grignolio et al. 2003, 2004, Lovari et al. 2006).

Land-cover Data. Data on habitat features were derived from the CORINE landcover database, satellite imagery data freely available for the European Union countries. Data on land morphology and altitude were derived from Digital Terrain Models (DTM) made available by Valle d'Aosta Autonomous Region and Piedmont Region. We calculated the availability of surface areas in nine altitude classes (in m above sea level, 700–1100; 1101–1400; 1401–1800; 1801–2200; 2201–2500; 2501–2900; 2901–3300; 3301–3700; >3700). Data were processed with ArcView 3.2.

Statistical Analysis. We analyzed altitudinal distribution of Bearded Vultures using a GLM in which the month and the age class were included as covariates. For this analysis, individuals were subdivided into the following age categories: young of the year, immature (1–2 yr), subadults (3–4 yr), adults (≥5 yr) and undetermined.

Statistical techniques were parametric or nonparametric, depending on distribution of data. Habitat selection was assessed with a chi-square test of habitat use (frequency of sightings in that habitat) versus availability (expected frequency based on random distribution of observations) and the application of Bonferroni simultaneous confidence intervals with $\alpha = 0.05$ (Byers et al. 1984). Statistical analyses were carried out with SPSS 16.0.

RESULTS

From January 1989 to July 2007, 1787 sightings of Bearded Vultures were recorded within the GPNP area. Some data were partial and could not be used for all analyses; 1577 sightings with reliable data on altitude were retained for analysis on altitude distribution in the park area and the immediate surroundings. A total of 1157 sightings that were made within the park were accompanied by complete data with precise location information; these data were used for the analyses of altitude and habitat selection.

The number of sightings per year increased from 7 in 1989 to a maximum of 321 in 2001 and was not correlated with the number of released captive-bred individuals during the same year in the western Alps (Spearman Rho = −0.032, $P = 0.90$); instead, it was positively correlated with the number released one year prior (Spearman Rho = 0.547, $P = 0.010$) and two years prior (Spearman Rho = 0.635, $P = 0.002$).

At least 21 different individuals were recognized on the basis of decolored feathers until the age of 2–3 yr. However, only eight individuals were observed at least ten times in the area, with a median frequency of 21.5 times. On the basis of these partial data we concluded that our data are not significantly affected by pseudo-replication.

Distribution of Sightings by Altitude. Average altitude of sightings varied through the calendar year. From January to May, when the terrain was covered by snow, Bearded Vultures were observed at an average altitude of 2018 m ($n = 829$, SE = 411), with more than half of the sightings below the tree line. From June to October, as snow melts, the birds were sighted at higher altitudes, an average of 2630 m ($n = 533$; SD = 412). In November and December, birds were observed at lower altitude, but mostly above the tree line (2189 m; $n = 215$; SD = 427). Sightings altitude differed significantly among months, but not among age classes. Our GLM with all years pooled indicated that altitude of sightings was significantly related to month ($n = 1577$; $P < 0.001$) but not age class ($P = 0.151$). There was also a significant interaction between month and age class ($P = 0.038$); the adjusted R^2 for the model was 0.336.

The altitude distribution of Bearded Vultures throughout the year showed the same pattern as those of the two most common ungulates of the GPNP, alpine ibex and alpine chamois (Fig. 1). The monthly average altitude of Bearded Vultures was positively correlated to average altitude of alpine ibex (Pearson $r = 0.97$, $n = 12$, $P < 0.001$) and alpine chamois (Pearson $r = 0.90$, $n = 12$, $P < 0.001$), as recorded by park wardens on patrol. The same pattern was apparent for data collected using radiotelemetry for ibexes and chamois, but these data were only available on a seasonal basis, so no statistical correlation could be calculated.

Considering the entire dataset, we found a significant difference from a random distribution of observations ($\chi^2_8 = 165$, $P < 0.001$). Altitude classes from m 1400 to m 2500 were used more often than expected; the other altitude classes were used less often (Table 1).

Habitat Use and Selection. The most frequently used habitats were, in decreasing order, vegetated

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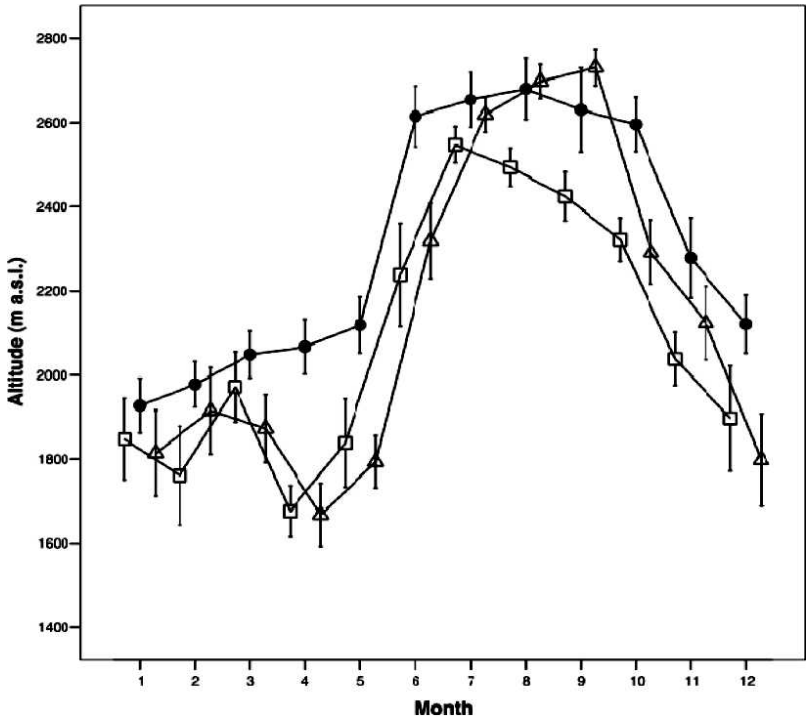


Figure 1. Average altitude (±1 SE) of Bearded Vulture ●, Alpine ibex △, and Alpine chamois □ in the Gran Paradiso National Park, Italy, in different months.

cliffs and screes, bare rocks, forest-scrub mosaic, alpine grassland, coniferous forests, alpine heaths and scrubs (Table 2). The observed frequency of Bearded Vultures in various habitats differed significantly from the expected frequency based on availability in the park ($\chi^2_{12} = 314.5$, $P < 0.001$). Three habitats were used with a frequency significantly higher than expected: vegetated cliffs and screes, forest-scrub mosaic, and agriculture. The latter habitat, however, was used rarely, with only 38 sightings

Table 1. Selection of terrain in different altitude classes by the Bearded Vulture in the Gran Paradiso National Park, Italy, with simultaneous Bonferroni confidence intervals and $\alpha = 0.05$. All seasons and all age classes were pooled ($n = 1157$); + = used significantly more frequently than expected if used in proportion to availability; − = used significantly less frequently than expected if used in proportion to availability.

Altitude Class (m)	Expected Proportion of Usage	Actual Proportion of Usage	Bonferroni Intervals for Actual Proportion of Usage		Selection
			Lower	Upper	
700–1100	0.013	0.001	−0.001	0.003	−
1100–1400	0.038	0.019	0.011	0.027	−
1400–1800	0.118	0.156	0.135	0.176	+
1800–2200	0.181	0.264	0.238	0.289	+
2200–2500	0.188	0.246	0.221	0.271	+
2500–2900	0.285	0.215	0.192	0.239	−
2900–3300	0.143	0.092	0.075	0.108	−
3300–3700	0.030	0.008	0.003	0.013	−
>3700	0.002	0.000	0.000	0.000	−

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Table 2. Selection of habitats by the Bearded Vulture in the Gran Paradiso National Park, with simultaneous Bonferroni confidence intervals and $\alpha = 0.05$. All seasons and all age classes were pooled ($n = 1157$). NS = frequency of use of the habitat not significantly different from expected if used in proportion to availability; + = used significantly more frequently than expected if used in proportion to availability; − = used significantly less frequently than expected if used in proportion to availability.

Habitat	Expected Proportion of Usage	Actual Proportion of Usage	Bonferroni Intervals for Actual Proportion of Usage		Selection
			Lower	Upper	
Hay meadows	0.002	0.010	0.002	0.019	NS
Agriculture	0.010	0.033	0.018	0.048	+
Agriculture with trees	0.004	0.003	0	0.007	NS
Broad-leaved forests	0.014	0.001	0	0.003	−
Coniferous forests	0.087	0.096	0.071	0.121	NS
Mixed forests	0.010	0.003	0	0.008	−
Alpine grassland	0.112	0.117	0.090	0.145	NS
Alpine heaths and scrubs	0.062	0.059	0.039	0.079	NS
Forest-scrub mosaic	0.079	0.149	0.119	0.180	+
Bare rocks	0.346	0.248	0.211	0.285	−
Vegetated cliffs and scree	0.210	0.274	0.236	0.312	+
Eternal snow and glaciers	0.060	0.006	0	0.013	−
Alpine lakes and reservoirs	0.006	0.001	0	0.003	−

recorded. Of the most frequently used habitats, bare rocks were used significantly less than expected based on availability. Other habitats were used in the same proportion as available, including the highly used alpine grassland, coniferous forests, and alpine heaths and scrubs.

Discussion

The increased number of Bearded Vulture sightings inside the GPNP since 1989 may be attributed to: (1) the release and survival of captive-born individuals, which increased annually, (2) the increased awareness among park personnel about the species, and/or (3) the high suitability of the GPNP habitat for the species. However, we believe that the second factor likely was only significant for the very first years; after that, observers were trained enough to ensure consistent effort from year to year.

The GPNP seemingly contains very suitable Bearded Vulture habitat. Hunting has been prohibited since 1923, and thus the park hosts large populations of the two mountain ungulates, the alpine ibex and the alpine chamois (Gambino 2002, Jacobson et al. 2004). Medium-sized mammals, including these two species, are the main food sources for Bearded Vulture (Hiraldo et al. 1979, Thibault et al. 1993, Margalida et al. 2009). Prospecting Bearded Vultures may explore wide areas and quickly assess the suitability of portions of the territory, choosing to stay longer in better areas; this is easier if the area is devoid of potential competitors of the same species, as happens at the beginning of recolonization after reintroduction (Hirzel et al. 2004).

Bearded Vultures using the GPNP frequented a variety of altitudes throughout the year. During warmer months, Bearded Vultures stayed at higher altitudes, and, when the terrain was mostly covered by snow, at lower altitudes. This pattern corresponded to the seasonal altitudes of the alpine ibex and the alpine chamois (Fig. 1), which make seasonal, vertical migrations. Alpine ibexes of the GPNP make rapid vertical migrations, in response to ambient temperature (Aublet et al. 2009). Alpine chamois show two different movement strategies inside the GPNP, as some males defend a territory almost year-round, usually at lower altitude, whereas other males are more vagrant and in summer frequent the same high altitudes that females do (von Hardenberg et al. 2000, Lovari et al. 2006). A strong correlation between the distribution of Bearded Vulture sightings and alpine ibex densities was found, on a wider scale, in the Canton Valais, Switzerland (25 km from the GPNP border) by Hirzel et al. (2004), who modelled the distribution of the Bearded Vulture and found that the species used areas with higher density of alpine ibex, but found

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no correlation to the more abundant and widespread alpine chamois.

Inside the GPNP, the Bearded Vulture used some habitats with a frequency significantly higher than expected based on availability. This might be due to a selection of the species for those habitats, which are similar to those used by the potential prey, or are important for their thermal properties. Overall, the Bearded Vulture in the GPNP largely uses open and semi-open habitats. During summer, alpine areas, which host high densities of alpine ungulates, are preferred. In winter, Bearded Vultures also frequent the forest-scrub mosaic at lower altitude, where potential prey seek refuge.

In the Alps, open and semi-open habitats exist due to climatic and topographic factors (e.g., altitude and slope), or anthropogenic factors, such as agriculture and livestock-raising. These latter factors are more important at lower altitudes. According to a recent review of causes of forest expansion in the Alps, land abandonment is the dominant factor even at the tree line ecotone level, and only a small fraction of upward shift can be attributed to the recent climate warming (Gehrig-Fasel et al. 2007). The Alps appear to have a natural inertia and thus to tolerate an increase of 1–2°C in mean air temperature, but for a change of the order of 3°C or more, profound changes may be expected (Theurillat and Guisan 2001). Land abandonment is proposed as the main factor affecting the survival of species linked to open areas below the tree line; in the Italian Alps, forecasts predict a scenario of habitat loss because of vegetation closure for the resident Golden Eagle (*Aquila chrysaetos*, Pedrini and Sergio 2001), the migratory Red-backed Shrike (*Lanius collurio*, Brambilla et al. 2009), and for breeding bird communities (Laiolo et al. 2004).

In the GPNP, the wide altitude range and the presence of vast areas of natural open and semi-open habitat, both at lower and higher altitude, will likely maintain suitable open and semi-open habitats for the Bearded Vulture within a scenario of low-intensity global warming, even in the absence of human activities. However, it may be a cause for concern that populations of alpine ibex, a main food of the Bearded Vulture, inside the GPNP are decreasing and this seems to be linked with climatic factors (Jacobson et al. 2004, Pettorelli et al. 2007).

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LITERATURE CITED

AUBLET, J.-F., M. FESTA-BIANCHET, D. BERGERO, AND B. BASSANO. 2009. Temperature constraints on foraging behaviour of male alpine ibex (*Capra ibex*) in summer. *Oecologia* 159:237–247.

BRAMBILLA, M., F. CASALE, V. BERGERO, G.M. CROVETTO, R. FALCO, I. NEGRI, P. SICCARDI, AND G. BOGLIANI. 2009. GIS-models work well, but are not enough: habitat preferences of *Lanius collurio* at multiple levels and conservation implications. *Biological Conservation* 142:2033–2042.

BYERS, C.R., R.K. STEINHORST, AND P.R. KRAUSMAN. 1984. Clarification of a technique for analysis of utilization-availability data. *Journal of Wildlife Management* 48: 1050–1053.

DONÁZAR, J.A., A. MARGALIDA, M. CARRETE, AND J.A. SÁNCHEZ-ZAPATA. 2009. Too sanitary for vultures. *Science* 326:664.

GAMBINO, R. 2000. Studi propedeutici per il piano del Parco Nazionale del Gran Paradiso. Ente Parco Nazionale Gran Paradiso, Torino, Italy.

GEHRIG-FASEL, J., A. GUISAN, AND N.E. ZIMMERMANN. 2007. Tree line shifts in the Swiss Alps: climate change or land abandonment? *Journal of Vegetation Science* 18: 571–582.

GRIFFITH, B., J.M. SCOTT, J.W. CARPENTER, AND C. REED. 1989. Translocations as a species conservation tool: status and strategy. *Science* 245:477–480.

GRIGNOLIO, S., F. PARRINI, B. BASSANO, S. LUCCARINI, AND M. APOLLONIO. 2003. Habitat selection in adult males of alpine ibex, *Capra ibex ibex*. *Folia Zoologica* 52:113–120.

———, I. ROSSI, B. BASSANO, F. PARRINI, AND M. APOLLONIO. 2004. Seasonal variations of spatial behaviour in female Alpine ibex (*Capra ibex ibex*) in relation to climatic conditions and age. *Ethology Ecology and Evolution* 16: 255–264.

GUIDALI, F., T. MINGOZZI, AND G. TOSI. 1990. Historical and recent distribution of lynx (*Lynx lynx* L.) in northwestern Italy during the 19th and the 20th centuries. *Mammalia* 54:587–596.

HEGGLIN, D. 2007. Novità dal progetto di telemetria satellitare ''Bearded Vultures on the Move.'' *Info Gipeto* 24: 22–23.

HIRALDO, F., M. DELIBES, AND J. CALDERON. 1979. El Quebrantahuesos (L.). Monografias 22. Instituto para la Conservaciòn de la Naturaleza, Madrid, Spain.

HIRZEL, A.H., B. POSSE, P.A. OGGIER, Y. CRETTENAND, C. GLENZ, AND R. ARLETTAZ. 2004. Ecological requirements of reintroduced species and the implications for release policy: the case of the Bearded Vulture. *Journal of Applied Ecology* 41:1103–1116.

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JACOBSON, A.R., A. PROVENZALE, A. VON HARDENBERG, B. BASSANO, AND M. FESTA-BIANCHET. 2004. Climate forcing and density dependence in a mountain ungulate population. *Ecology* 85:1598–1610.

LAIOLO, P., F. DONDERO, E. CILIENTO, AND A. ROLANDO. 2004. Consequences of pastoral abandonment for the structure and diversity of the alpine avifauna. *Journal of Applied Ecology* 41:294–304.

LOVARI, S., F. SACCONI, AND G. TRIVELLINI. 2006. Do alternative strategies of space use occur in male alpine chamois? *Ethology Ecology and Evolution* 18:221–231.

MARGALIDA, A., J. BERTRAN, AND R. HEREDIA. 2009. Diet and food preferences of the endangered Bearded Vulture *Gypaetus barbatus*: a basis for their conservation. *Ibis* 151:235–243.

———, J.A. DONÁZAR, J. BUSTAMANTE, F.J. HERNANDEZ, AND M. ROMERO-PUJANTE. 2008. Application of a predictive model to detect long-term changes in nest-site selection in the Bearded Vulture *Gypaetus barbatus*: conservation in relation to territory shrinkage. *Ibis* 150:242–249.

MINGOZZI, T. AND R. ESTÈVE. 1997. Analysis of a historical extirpation of the Bearded Vulture *Gypaetus barbatus* (L.) in the western Alps (France-Italy): former distribution and causes of extirpation. *Biological Conservation* 79:155–171.

PEDRINI, P. AND F. SERGIO. 2001. Golden Eagle *Aquila chrysaetos* density and productivity in relation to land abandonment and forest expansion in the Alps. *Bird Study* 48:194–199.

PETTORELLI, N., F. PELLETIER, A. VON HARDENBERG, M. FESTA-BIANCHET, AND S.D. COTE. 2007. Early onset of vegetation growth vs. rapid green-up: impacts on juvenile mountain ungulates. *Ecology* 88:381–390.

THEURILLAT, J.P. AND A. GUISAN. 2001. Potential impact of climate change on vegetation in the European Alps: a review. *Climate Change* 50:77–109.

THIBAULT, J.C., J.D. VIGNE, AND J. TORRE. 1993. The diet of young Lammergeiers *Gypaetus barbatus* in Corsica: its dependence on extensive grazing. *Ibis* 135:42–48.

VON HARDENBERG, A., B. BASSANO, A. PERACINO, AND S. LOVARI. 2000. Male alpine chamois occupy territories at hotspots before the mating season. *Ethology* 106:617–630.

ZINK, R. 2007. International Bearded Vulture monitoring in the Alps. Pages 69–72 *in* H. Frey, G. Schaden, and P. Fasce [EDS.], Bearded Vulture Annual Report 2006. Foundation for the Conservation of the Bearded Vulture, Gugler Cross Media, Melk, Austria.

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