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Influence of climate on Bonelli's eagle's (*Hieraaetus fasciatus* V. 1822) breeding success through the Western Mediterranean

Diego Ontiveros* and Juan M. Pleguezuelos *Departamento de Biología Animal y Ecología, Facultad de Ciencias, Universidad de Granada, E-18071 Granada, Spain*

Abstract

Aim To assess the impact of certain climatic variables on the breeding success of some populations of Bonelli's eagle (*Hieraaetus fasciatus* V. 1822) throughout its latitudinal distribution range, in order to account for recent and differential declines in populations.

Location Western Mediterranean, from southern Morocco to southern France.

Methods Seven populations were considered for the latitudinal distribution range of the species. Data from 1052 breeding attempts were taken from the literature and, for each population, breeding success was measured as the mean number of fledglings per pair per year. Breeding success, as a dependent variable, was related to five geographical and climatic variables (latitude, mean annual temperature, mean minimum temperature of the coldest month, mean maximum temperature of the hottest month and mean annual precipitation) as independent variables, through some regression models, which take into account the multicolinearity of the variables.

Results All the analyses agreed that average annual temperature was an important factor associated with the breeding success of the species in each region, and accounted for up to 97% of the variance of the breeding success throughout a latitudinal gradient in the study area.

Main conclusions The low breeding success of the northern populations (probably because of climatic constraints) and the tendency of juveniles to disperse southwards, diminishes recruitment in those populations. Therefore, as human pressure and habitat destruction causes high adult and pre-adult mortality of the species throughout its entire latitudinal range, disturbances in the northern populations have more profound effects, thereby explaining observed population declines.

Keywords
Bonelli's eagle, breeding success, climate, Western Palearctic.

INTRODUCTION

Climate, topography and food supply are factors which can influence species' geographical distribution (Rapoport, 1982). Anything that tends to make it more difficult for a species to live, grow or reproduce in its environment is a limiting factor for the species in that environment (Cox & Moore, 2000). In this sense, climate is one of the major factors influencing the distribution patterns of many species through its influence on demographic rates across a geographical range (Caughtley *et al.*, 1988; Root, 1988; Hoffmann & Blows, 1994; Vernier *et al.*, 1999).

Many factors may be involved in the differential breeding success of raptors throughout their distribution area, such as differences between regions, habitats or territories (Gargett, 1977; Watson *et al.*, 1992; Donázar *et al.*, 1993), and the influence of parasites, diseases and weather (Collias & Collias, 1984). In this way, avian reproduction may be highly influenced by temperature (Wingfield, 1984).

Bonelli's eagle (*Hieraaetus fasciatus* V. 1822) is an accipitrid that, in the Western Palearctic, is confined to the Mediterranean area, from southern Morocco to southern

*Correspondence: Diego Ontiveros, Departamento de Biología Animal y Ecología, Facultad de Ciencias, Universidad de Granada, E-18071 Granada, Spain. E-mail: dontive@ugr.es

France (Cramp & Simmons, 1980). The European population is estimated at 938–1039 breeding pairs, 80% living in Spain (Real *et al.*, 1996). In recent decades the eagle has undergone one of the most severe population declines recorded among birds of prey, and has been listed as an endangered European species (Rocamora, 1994). According to Real & Mañosa (1997), for the 1980–94 period, 12.5% of pairs disappeared from Provence (France), 42.8% from Burgos (Spain), 32.1% from Vallès-Penedès (Spain), 39.1% from Castellón (Spain), and according to Carrete *et al.* (2002), for the 1983–1997 period, 51.4% of pairs disappeared from Murcia (Spain). In Western Europe, only southern populations have remained stable in recent years (Ontiveros, 2000; Dobado-Berrios *et al.*, 2001). Consequently, this eagle has been classified as vulnerable in Spain (IUCN categories; Blanco & González, 1992), and high-priority conservation measures have been called for (De Juana, 1992).

Several hypotheses have been proposed to explain the decline in Bonelli's eagle populations in recent decades: habitat destruction (Rocamora, 1994; Arroyo *et al.*, 1995), persecution (Arroyo *et al.*, 1995), power-line casualties (Cheylan, 1994), and disturbances at nesting sites (Rocamora, 1994; Ontiveros, 1999). The shift in breeding success of the Bonelli's eagle and the population decline attributed to the prey availability showed contradictory results (Cugnase, 1989; Ontiveros & Pleguezuelos, 2000). However, the influence of climate on the breeding success of Bonelli's eagle has never been studied, despite many studies reporting a relationship between climate and breeding success in raptors (Marti, 1994; Corbacho *et al.*, 1997; North *et al.*, 2000; García & Arroyo, 2001), and, in the Western Mediterranean, there is a clear change in breeding success among populations located on a north–south axes (Real & Mañosa, 1997).

The aim of the present paper is to analyse the impact of latitude, temperature and rainfall on the breeding success of Western Mediterranean Bonelli's eagle populations, from the upper to the lower limit of its distribution range, in order to account for the varying rates of recent population declines in different geographical areas.

STUDY AREA AND METHODS

We compared the breeding success in seven Bonelli's eagle populations in the Western Mediterranean region (Provence, Burgos, Vallès-Penedès, Castellón, Murcia, Granada and Morocco; Fig. 1). These populations comprise the latitudinal distribution range of the species in the Western Palearctic (28°50′–44°05′ N).

Data on a total of 1052 breeding attempts were obtained from the literature: data from Real & Mañosa (1997) for Provence, Vallès-Penedès, Burgos, Castellón and Murcia; from Ontiveros (2000) for Granada; and from Bergier & Naurois (1985) for Morocco. For the accuracy of data, only populations having more than seventy-five breeding attempts were included in the analysis (except for the Morocco population; Fig. 1). The average number of fledglings produced per occupied territory per year was used as a measure of breeding success (Steenhof *et al.*, 1997).

Several studies have reported a relationship between climatic variables and breeding success of different bird

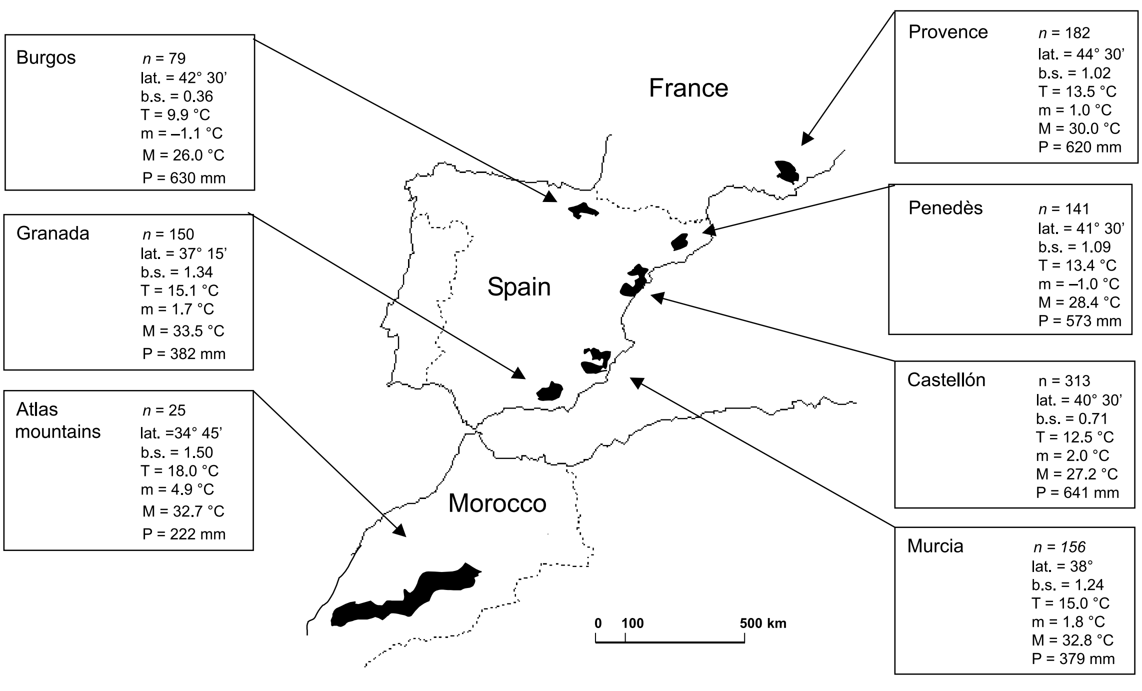

Figure 1 Geographical location for the seven populations of Bonelli's eagle (*Hieraaetus fasciatus* V. 1822) analysed in Western Mediterranean. *n*, sample size; lat, latitude; b.s., breeding success; *T*, average annual temperature; *m*, average minimum temperature of the coldest month (January); *M*, average maximum temperature for the hottest month (July); *P*, precipitation.

species: low winter temperatures (Marti, 1994), rainfall and temperature (North *et al.*, 2000; Reid *et al.*, 2000; García & Arroyo, 2001), and latitude (Corbacho *et al.*, 1997). In this way, the breeding success values were related to geographical and climatic data for the study area: latitude (lat); average annual temperature (T); average minimum temperature of the coldest month, January (m); average maximum temperature of the hottest month, July (M); and precipitation (P). Climatic data were taken from Météo-France (1999) for the Provence, INM (1995) for Spain, and L'Houerou (1989) for Morocco (30-year standard meteorological averages).

For the statistical analysis of the influence of independent variables on the dependent variable, it is crucial to test for multicolinearity among the former, as this can be a serious problem for later analysis (Leamer, 1973). After assessing for multicolinearity among independent variables (see Results), we sought a single 'best' regression model by performing a stepwise multiple regression (Nicholls, 1989) using the ridge method, which minimizes the effects of multicolinearity (Hoerl, 1962; Price, 1977). Notwithstanding, the predictive models can be improved by the performance of all possible regression models, which should agree with the single best model in which the independent variables are more likely to be significant (MacNally, 2000). Therefore, we first made a linear correlation between average breeding success of each population (dependent variable) and the geographical and climatic variables (independent variables). Secondly, we made a multiple correlation between dependent and independent variables using standard and backward methods. Thirdly, we performed hierarchical partitioning (Chevan & Sutherland, 1991), which involves the calculation of the incremental improvement in the model by the addition of a given variable, to provide a measure of the effects of independent variables (Christensen, 1992).

RESULTS

Indicators of high redundancy among independent variables were found. Thus, there was a low tolerance (1 – redundancy of independent variables) for five variables (mean = 0.16 ± 0.05), and the estimated β (standardized regression coefficient) for some variables exceeded 1.0 as a result of multicolinearity (Price, 1977). The forward ridge regression model, performed with $\lambda = 0.003$ (which stabilized the β-values), selected the variables – average annual temperature and average minimum temperature – to explain breeding success variability ($F_{2,4} = 67.6$, $R^2 = 0.971$; $P = 0.0008$).

When testing univariate correlations, only two variables partially correlated with breeding success, average annual temperature and average maximum temperature (Table 1). The standard multiple regression model included only the average annual temperature as a significant predictive variable ($F_{1,5} = 261.2$, $R^2 = 0.999$; $P = 0.04$). The same was true for the stepwise backward selection ($F_{1,5} = 52.3$, $R^2 = 0.913$; $P = 0.0008$). Finally, the exploratory analysis revealed that average annual temperature has a substantially greater independent explanatory power than other variables.

Table 1 Correlation between breeding success (average number of fledglings per pair per year) and climatic variables

	Latitude (°)	T (°C)	m (°C)	M (°C)	P (mm)
r	−0.70	0.96	0.66	0.91	−0.72
P	0.078	0.0007*	0.10	0.003*	0.06

*Tests that remain significant ($P < 0.05$) after Bonferroni sequential correction (Rice, 1989). For explanations of variables see Methods.

Thus, the percentage of independent effects calculated from hierarchical partitioning was 91.5% for average annual temperature, 6.1% for average minimum temperature, 1.2% for average maximum temperature, 0.9% for rainfall, and 0.1% for latitude.

All statistical approaches identified average annual temperature as the parameter most associated with the breeding success of Bonelli's eagle throughout a latitudinal gradient in Western Mediterranean. According to the best regression model, this variable explains 97% of the variance in breeding success. Thus, climate has a strong influence on Bonelli's eagle reproduction. All this occurs in spite of the lack of annual variation in climate during the study period for each region, measured as the relationship between years and mean annual temperature ($P > 0.23$, in the six regions for which data was available). In this way, the Granada population of Bonelli's eagle (for which only we have data of annual productivity) showed homogeneity in breeding success during the 1994–2002 period (Kruskal–Wallis = 7.14; d.f. = 8; $P = 0.52$).

DISCUSSION

The distribution of this eagle, whether considered on a geographical, habitat or microhabitat scale, is surrounded by areas where the species cannot maintain a population because changes in physical conditions do not permit its survival. Within the range of optimum distribution, a species can survive and maintain large populations; beyond it, towards both the low and the high ends of the gradient, the species suffers increasing physiological stress, maintaining only low populations (Cox & Moore, 2000). The negative effects of climate on reproduction, and therefore on population growth rates, are more likely to be greatest at range boundaries (Hoffmann & Blows, 1994). Such effects have been reported in other raptors, such as the Barn Owl (*Tyto alba* S. 1769; Marti, 1994), the Golden Eagle (*Aquila chrysaetos* L. 1758; Steenhof *et al.* 1997), the California Spotted Owl (*Strix occidentalis* X. 1860; North *et al.*, 2000), the Hen Harrier (*Circus cyaneus* L. 1766) and the Montagu's Harrier (*Circus pygargus* L. 1758; García & Arroyo, 2001).

According to our results, the average annual temperature is the main climatic variable explaining the breeding success of Bonelli's eagle throughout its latitudinal range in the Western Mediterranean. Populations of Bonelli's eagle in the coldest areas show lower breeding success than those in the hottest areas within the Western Mediterranean. Some studies have in fact found that temperature is associated with the breeding success of birds, either positively (Kostrzewa, 1989; Kostrzewa & Kostrzewa, 1991; Sheaffer & Malecki, 1996; Pasinelli, 2001) or negatively (Tomback & Murphy, 1981; Steenhof *et al.*, 1997; Moss *et al.*, 2001). Average annual temperature is a deterministic parameter during certain periods of the raptor's life history, including egg production, hatching, and the period when young chicks in nest are unable to thermoregulate efficiently and depend on the brooding behaviour of their parents (Elkins, 1983). Cold temperatures may increase the metabolic rate to counteract heat loss, so that more energy reserves within the body are utilized during cold weather, leading to greater food demands of the young and brooding adults (Weathers, 1979; Nager & van Noordwijk, 1982). This situation may be especially important for a raptor species that is confined to the Mediterranean area; this species having the earliest breeding season among all the European eagles, with most of the young leaving the nest as early as May (Cramp & Simmons, 1980).

Mortality and breeding success are major traits influencing the population dynamics of raptors (Newton, 1997). Here, we analyse only breeding success, because some of the populations under consideration differed by 416%, whereas adult mortality was similar among populations, at least in six of the seven populations under consideration (Real & Mañosa, 1997; Ontiveros, 2000).

Among hypotheses to explain the decline in Bonelli's eagle populations in recent decades (see Introduction), climate has not previously been considered, although our results imply that these effects would clarify the current decline in some populations. Bonelli's eagle is known to be confined to fairly warm and dry regions (Cramp & Simmons, 1980), and with the results of the present study, we have shown that the breeding success of Bonelli's eagle in the Western Mediterranean is very strongly associated with climate. Although we do not know the specific mechanism involved, the effect of climate probably acts through a physiological constraint. Climate has not been considered a problem for the conservation of Bonelli's eagle populations located at the ends of their distribution range in the past, but some threats have arisen in recent decades. Currently, in the study area, this raptor suffers high adult and pre-adult mortality (Real & Mañosa, 1997; Ontiveros, 2000; Carrete *et al.*, 2002), and human pressures cause the abandonment of nests and traditionally occupied territories (Rocamora, 1994; Arroyo *et al.*, 1995; Ontiveros, 1999). In this scenario, the low breeding success of northern populations does not compensate for mortality and habitat destruction, which would account for the regression of these northerly populations. In the south, negative factors would be of the same severity as in the north, but are offset by high productivity of the pairs (Fig. 1), and the tendency of juveniles of northern populations to disperse southwards (Real & Mañosa, 2001).

The North African populations are clearly limited to the south by the northern border of the Sahara desert (29° latitude), which prevents the extension of the breeding range southwards (in Asia the species extends a further 10° of latitude southwards; Cramp & Simmons, 1980). Therefore, the Moroccan populations are not at the distribution limit in terms of temperature, but they are probably within the optimum distribution range of the species, and show the highest breeding success for the species in Western Mediterranean.

In summary, human pressures interfering with nesting areas, and climatic conditions that act to reduce breeding success at the northern limits of its distribution range, are important factors limiting the growth rates of Bonelli's eagle populations in the Western Mediterranean. Conservation efforts in this area must be directed primarily towards increasing adult and pre-adult survival (Real & Mañosa, 1997). The measure would be especially important for northern populations, which are handicapped by adverse climate (low mean annual temperature) and juvenile dispersal to the south.

REFERENCES

Arroyo, B., Ferreiro, E. & Garza, V. (1995) *El Águila Perdicera (Hieraaetus fasciatus) en España. Censo, reproducción y conservación*, p. 43. Serie Técnica, ICONA. Madrid.

Bergier, P. & Naurois, R. (1985) Note la reproduction de l'Aigle de Bonelli *Hieraaetus fasciatus* en Afrique du Nord-ouest. *Alauda*, **53**, 257–262.

Blanco, J.C. & González, J.L. (1992) *Libro rojo de los vertebrados de España*, p. 331. ICONA, Colección Técnica, Madrid.

Carrete, M., Sánchez-Zapata, J.A., Martínez, J.E., Sánchez, M.A. & Calvo, J.F. (2002) Factors influencing the decline of a Bonelli's eagle population *Hieraaetus fasciatus* in southeastern Spain: demography, habitat or competition? *Biodiversity and Conservation*, **11**, 975–985.

Caughtley, G., Grice, D., Barker, R. & Brown, B. (1988) The edge of the range. *Journal of Animal Ecology*, **57**, 771–785.

Chevan, A. & Sutherland, M. (1991) Hierarchical partitioning. *The American Statisticacian*, **45**, 90–96.

Cheylan, G. (1994) Aigle de Bonelli. *Atlas des oiseaux nicheurs de France 1985–1989* (eds D. Yéatman-Berthelot and G. Jarry), pp. 200–201. Société Ornithologique de France, Paris.

Christensen, R. (1992) Comment on Chevan and Sutherland. *American Statistician*, **45**, 90–96.

Collias, N.E. & Collias, E.C. (1984) *Nest building and bird behaviour*, pp. 87–141. Princenton University Press, Princeton, NJ.

Corbacho, C., Sánchez, J.M. & Sánchez, A. (1997) Breeding biology of Montagus Harrier *Circus Pygargus* L. in agricultural environments of southwest Spain: a comparison with other populations in the Western Palearctic. *Bird Study*, **44**, 166–175.

Cox, C.B. & Moore, P.D. (2000) *Biogeography: an ecological and evolutionary approach*, 6th edn, pp. 34–52. Blackwell Science Ltd, Oxford.

Cramp, S. & Simmons, K.L. (1980) *The birds of the Western Paleartic*, Vol. II. Oxford University Press, Oxford.

Cugnase, J.M. (1989) Schutzstrategien für den Habichtsadler (*Hieraaetus fasciatus*) im Französischen Languedoc-Roussillon. *Laufener Seminarbeitr*, **1**, 65–66.

De Juana, E. (1992) Algunas prioridades en la conservación de aves en España. *Ardeola*, **39**, 73–84.

Dobado-Berrios, P.M., Álvarez, R. & Domínguez, J.C. (2001) Demographic parameters of a Bonelli's eagle (*Hieraaetus* *fasciatus*) populations in Southern Spain. *Abstracts of the 4th Eurasian Congress on Raptors* (ed. Estación Biológica Doñana and Raptor Research Foundation), p. 57. Sevilla, Spain.

Donázar, J.A., Hiraldo, F. & Bustamante, J. (1993) Factors influencing nest site selection, breeding density and breeding success in the bearbed vulture (*Gypaetus barbatus*). *Journal of Applied Ecology*, **30**, 504–514.

Elkins, N. (1983) *Weather and bird behaviour*. T. & A.D. Poyser.

García, J.T. & Arroyo, B.E. (2001) Effect of abiotic factors on reproduction in the centre and periphery of breeding ranges: a comparative analysis in sympatric harriers. *Ecography*, **24**, 393–402.

Gargett, V. (1977) A 13-year population study of the Black Eagles in the Matopos, Rhodesia, 1964–1976. *Ostrich*, **48**, 17–27.

Hoerl, A.E. (1962) Application of ridge analysis to regression problems. *Chemical Engineering Progress*, **58**, 54–59.

Hoffmann, A.A. & Blows, M.W. (1994) Species borders: ecological and evolutionary perspectives. *Trends in Ecology and Evolution*, **9**, 223–227.

INM (1995) *Guía resumida del clima en España, 1961–1990*, Madrid.

Kostrzewa, A. (1989) The effect of weather on density and reproduction success in Honey Buzzards *Pernis apivorus*. Raptors in the Modern World (eds B.U. Meyburg and R.D. Chancellor), pp. 187–191. Proceedings of the Third World Conference of Birds of Prey and Owls, WWGBP, Berlin.

Kostrzewa, A. & Kostrzewa, R. (1991) Winter weather, spring and summer density, and subsequent breeding success of Eurasian kestrels, common buzzards and northern goshawks. *Auk*, **108**, 342–347.

L'Houerou, H.N. (1989) Classification ecoclimatique des zones arides (s.l.) de l'Afrique du Nord. *Ecologia Mediterránea*, **15**, 95–144.

Leamer, E.E. (1973) Multicollinearity: a Bayesian interpretation. *Review of Economics and Statistics*, **55**, 371–380.

Météo-France (1999) *Le climat de la France*. CD. Serv. Doc. Météo-France, Paris.

MacNally, R. (2000) Regression and model-building in conservation biology, biogeography and ecology: the distinction between – and reconciliation of – 'predictive' and 'explanatory' models. *Biodiversity and Conservation*, **9**, 655–671.

Marti, C.D. (1994) Barn Owl reproduction: patterns and variation near the limit of the species distribution. *Condor*, **96**, 468–484.

Moss, R., Oswald, J. & Baines, D. (2001) Climate change and breeding success: decline of the Capercaillie in Scotland. *Journal of Animal Ecology*, **70**, 47–61.

Nager, R.G. & Van Noordwijk, A.J. (1982) Energetic limitation in the egg-laying period of great tits. *Proceedings of the Royal Society of London, B*, **249**, 259–263.

Newton, I. (1997) *Population ecology of raptors*. T. and A. D. Poyser, Berkhamsted.

Nicholls, A.O. (1989) How to make biological surveys go further with generalised linear models. *Biological Conservation*, **50**, 51–75.

North, M., Steger, G., Denton, R., Eberlein, G., Munton, T. & Johnson, K. (2000) Association of weather and nest-site structure with reproductive success in California spotted owls. *Journal of Wildlife Management*, **64**, 797–807.

Ontiveros, D. (1999) Selection of nest cliff by Bonelli's eagle (*Hieraaetus fasciatus*) in southeastern Spain. *Journal of Raptor Research*, **33**, 110–116.

Ontiveros, D. (2000) *Ecología de una población de Águila Perdicera (Hieraaetus fasciatus) del sureste ibérico: plan de conservación*. PhD Thesis, Universidad de Granada, Granada.

Ontiveros, D. & Pleguezuelos, J.M. (2000) Influence of prey densities in the distribution and breeding success of Bonelli's eagle (*Hieraaetus fasciatus*): management implications. *Biological Conservation*, **93(1)**, 19–25.

Pasinelli, G. (2001) Breeding performance of the Middle Spotted Woodpecker *Dendrocopos medius* in relation to weather and territory quality. *Ardea*, **89**, 353–361.

Price, B. (1977) Ridge regression: application to nonexperimental data. *Psychological Bulletin*, **84**, 759–766.

Rapoport, E.H. (1982) *Aerography: geological strategies of species*. Pergamon, Oxford.

Real, J. & Mañosa, S. (1997) Demography and conservation of Western European Bonelli's Eagle (*Hieraaetus fasciatus*) populations. *Biological Conservation*, **79**, 59–66.

Real, J. & Mañosa, S. (2001) Dispersal of juvenile and inmature Bonelli's Eagle in norteastern Spain. *Journal of Raptor Research*, **35**, 9–14.

Real, J., Mañosa, S. & Codina, J. (1996) Estatus, demografía y conservación del Águila perdicera (*Hieraaetus fasciatus*) en el Mediterráneo. *Biología y conservación de las rapaces Mediterráneas* (eds J. Muntaner and J. Manyol), pp. 83–89. Monografía No. 4 SEO, Madrid.

Reid, J.M., Monaghan, P. & Ruxton, G.D. (2000) Resource allocation between reproductive phases: the importance of thermal conditions in determining the cost of incubation. *Proceedings of the Royal Society of London B*, **267**, 37–41.

Rice, W.R. (1989). Analyzing tables of statistical tests. *Evolution* **43**, 223–225.

Rocamora, G. (1994) Bonelli's eagle *Hieraaetus fasciatus*. *Birds in Europe, their conservation status* (eds G.M. Tucker and M.F. Heath), pp. 184–185. Birdlife International, Birdlife Conservation, Ser. 3, Cambridge, UK.

Root, T. (1988) Environmental factors associated with avian distributional boundaries. *Journal of Biogeography*, **15**, 489–505.

Sheaffer, S.E. & Malecki, R.A. (1996) Predicting breeding ecology in three european harriers (*Circus*). *Ardea*, **66**, 77–102.

Steenhof, K., Kochert, M.N. & McDonald T.L. (1997) Interactive effects of prey and weather on golden eagle reproduction. *Journal of Animal Ecology*, **66**, 350–362.

Tomback, D.F. & Murphy, J.R. (1981). Food deprivation and temperature regulation in nestling ferruginous hawks. *Wilson Bulletin*, **93**, 92–97.

Vernier, L.A., McKenney, D.W., Wang, Y. & Mckee J. (1999) Models of large-scale breeding-bird distribution as a function of macro-climate in Ontario, Canada. *Journal of Biogeography*, **26**, 315–328.

Watson, J., Rae, S.R. & Stillman, R. (1992) Nesting density and breeding success of golden eagles in relation to food supply in Scotland. *Journal of Animal Ecology*, **61**, 543–550.

Weathers, W. (1979) Climatic adaptation in avian standard metabolic rate. *Oecologia*, **42**, 81–89.

Wingfield, J.C. (1984) Influence of weather on reproduction. *Journal of Experimental Zoology*, **232**, 589–597.

BIOSKETCHES

Diego Ontiveros gained his PhD from the University of Granada through a study of the ecology of Bonelli's eagle in the southeastern region of the Iberian peninsula.

Dr Juan M. Pleguezuelos is a Professor in the same University, where he is Head of a Research Group focusing on the biology and ecology of vertebrates.

Both authors have published widely on raptors, and most especially on Bonelli's eagle, in journals including *Biological Conservation, Biodiversity and Conservation, The Journal of Raptor Research* and *The Journal of Zoology*. Currently, they are designing measures to aid the recovery of its threatened populations.