

Sexual selection, range size and population size

ANDERS PAPE MØLLER¹ & LÁSZLÓ ZSOLT GARAMSZEGI²



Anders Pape Møller & László Zsolt Garamszegi 2012. Ivari szelekció, elterjedési terület és populációméret. – Ornis Hungarica 20(1): 1–25.

Abstract Sexual selection may impose fitness costs on both males and females due to the costs of developing and maintaining exaggerated sexual signals, reducing average fitness in strongly sexually selected species. Such reductions in average fitness could affect local extinction risk and hence distribution range. However, given that both sexually monochromatic and dichromatic species are common and widespread, benefits of sexual selection must be invoked to maintain equilibrium. We tested for differences in breeding range size and population size between monochromatic and dichromatic species of birds in a comparative analysis of species from the Western Palearctic. In an analysis of standardized linear contrasts of the relationship between sexual dichromatism and range size and population size, respectively, that controlled for similarity among taxa due to common descent, we found no significant relationship. However, when we analyzed carotenoid-based sexual dichromatism sexually dichromatic species had larger distribution areas and higher northernmost distribution limits, but not southernmost distribution limits than sexually monochromatic species. In contrast, melanin-based sexual dichromatism was not significantly associated with range size or population size. Therefore, population density of sexually dichromatic species with carotenoid-based coloration was lower than that of monochromatic species, because dichromatic species had similar population sizes but larger ranges than monochromatic species. These findings suggest that the different physiological roles of pigments associated with sexual dichromatism have effects on total range size of birds.

Keywords: birds, carotenoids, melanin, sexual dichromatism, sexual selection

Összefoglalás Az ivari szelekció kihatással lehet az egyedi rátermettségre mind hímeknél, mind a tojóknál, mert a másodlagos nemi jellegek kifejllesztése és fenntartása bizonyos költségekkel terhelték, melyek visszahatnak a rátermettségre az erősen ivari szelekció alatt álló fajoknál. A rátermettségben megmutakozó költségek további befolyással bírnak a helyi extinkciós rátára, és így az elterjedési területre. Ennek ellenére úgy tűnik, hogy az ivarilag monokromatikus és dikromatikus fajok gyakoriak és elterjedtek, így az ivari szelekció előnyei egyensúlyt teremtenek a költségekkel. Jelen komparatív vizsgálatban azt teszteltük a nyugati Palearktikus régióban költő madaraknál, hogy az ivarilag monokromatikus és az ivarilag dikromatikus fajok elterjedési területe és populációmérete is különbözik-e. A lineáris standardizált kontrasztok módszerét használva, amikor a fajok közötti rokonsági kapcsolatot is számításba vettük, nem találtunk összefüggést a vizsgált változók között. Amikor azonban csak a karotin alapú színezetre fókuszáltunk, kiderült, hogy a dikromatikus fajoknak nagyobb és északabbra nyúló elterjedési területe van, mint a monokromatikus fajoknak. Ezzel szemben, a melanin alapú színezetre nem találtunk ilyen összefüggést. Az eredményekből még arra is következtettünk, hogy a karotin alapon dikromatikus fajok populációs denzitása alacsonyabb, mint karotin alapon monokromatikus fajoké, mert a dikromatikus fajok hasonló populációmérettel bírnak, mint a monokromatikus fajok. Összességében elmondhatjuk, hogy valószínűleg a különböző pigmentekhez kapcsolódó fiziológiai mechanizmusok különböző szerepet játszanak az ivari dikromatizmus és az elterjedési területek kapcsolatának fenntartásában a madaraknál.

Kulcsszavak: madarak, karotinoidok, melanin, ivari dikromatizmus, ivari szelekció

¹Laboratoire d'Ecologie, Systematique et Evolution, Université Paris-Sud, Orsay France, ²Department of Evolutionary Ecology, Estacion Biologica de Donana-CSIC, Seville, Spain, e-mail: laszlo.garamszegi@ebd.csic.es

Introduction

Sexual selection arises from the fitness advantages of certain individuals over others in competition for mates, resulting in the evolution of exaggerated secondary sexual characters (Darwin 1871). While the variance in individual mating success increases as a consequence of sexual selection, this increase in variance may also have important implications for population processes. For example, an increase in the variance in reproductive success may increase demographic stochasticity with consequences for extinction risk (Sæther *et al.* 2004). Furthermore, average fitness of individuals of strongly sexually selected species may be reduced compared to species subject to less intense sexual selection, and such load due to sexual selection will invariably suppress population size relative to that expected in the absence of sexual selection (Tanaka 1996). However, the world is full of widespread and common monochromatic and dichromatic species, implying that sexual selection may also be advantageous. Given that the proportion of sexually dichromatic species is variable among taxa, and that dichromatism has evolved numerous times (Price & Birch 1996), we can assume that benefits as well as costs are present, maintaining the frequency of sexual dichromatism at an equilibrium level.

The effects of sexual selection on population processes should be visible at, at least, three different levels. First, individuals should differ in their ability to cope with the costs of sexual selection, with mating success, fecundity and viability being related to the expression of secondary sexual characters as predicted by models of condition-dependent secondary sexual characters (Andersson 1994). This should have

consequences for the variance in individual contributions to populations. Second, populations consist of individuals that differ in their degree of sexual ornamentation, and this should have consequences for the local risk of extinction. Accordingly, Doherty *et al.* (2003) have shown for bird census data from North America that local extinction risk and local turnover rate are greater for sexually dichromatic than for monochromatic species. Therefore, it is not surprising that Doherty *et al.* (2003) for North American birds and Prinzing *et al.* (2002) for European birds did not find a relationship between sexual dichromatism and population trends because local extinctions would be expected to be balanced by a high local turnover rate. Third, given that species differ inherently in the costs and benefits of sexual selection, we should expect sexually dichromatic species to run greater risks of extinction than monochromatic species. Indeed, McLain *et al.* (1995, 1999) and Sorci *et al.* (1998) have shown for introduced birds to oceanic islands that the risk of immediate extinction is elevated for dichromatic compared to monochromatic species, even when controlling for potentially confounding variables such as inoculate size.

While numerous studies have investigated the effects of sexual selection on fitness components at the level of individuals, relatively few studies have investigated the effects of sexual selection at the population or species level. Here we test the prediction that population size, distribution range and northernmost and southernmost distribution limits differ between species that vary in the intensity of sexual selection. We used sexual dichromatism as a proxy for sexual selection, given that mating success (Gontard-Danek & Møller 1999) and fertilization success are positively related to sexual di-

chromatism within species (Møller & Ninni 1998). Similar patterns also occur among species (Andersson 1994, Møller & Birkhead 1994, Petrie *et al.* 1998). If sexual selection imposed significant average costs upon individuals of a species, we would expect population size more often to be suppressed in sexually dichromatic than in monochromatic species. Likewise, if such costs of sexual signals were present at the population level, we would expect marginal populations of sexually dichromatic species more often to go extinct (Doherty *et al.* 2003), resulting in a reduction in range size of sexually dichromatic species. We tested these predictions by analyzing range size and population size of the breeding birds of the Western Palaearctic because reliable information is readily available for the entire fauna. We have chosen range size and population as proxies of the effects of sexual selection at the species level, because these traits can be measured in a standard way in a large number of species. We assume that interspecific differences in range size, distribution limits and population size reflect the outcome of population processes that occur due to local extinction risk and demographic stochasticity that may be affected by the interspecific variance in reproductive success.

Sexual coloration can be based on pigments or structural color, and pigment-based coloration can be due to carotenoids or melanins. Previous studies have implicated such pigments in various physiological functions such as free radical scavenging and immune function (e.g. McGinness *et al.* 1970, Krinsky 1989, 1998, Rózanowska *et al.* 1999, Møller *et al.* 2000, Moreno & Møller 2006), suggesting a trade-off between plumage coloration and physiological function. Therefore, we assessed sexual dichromatism

for carotenoid and melanin based coloration to test explicitly if the population consequences of sexual selection differed between these two pigment categories.

Materials and methods

Study species

We included all bird species with a main breeding distribution within the Western Palaearctic (Cramp & Perrins 1977–1994) that resulted in a sample of 526 birds.

Sexual dichromatism

We scored the breeding plumage of all species as sexually monochromatic if males and females did not differ in coloration according to information provided by the descriptions in Cramp and Perrins (1977–1994), and otherwise as sexually dichromatic. This procedure was repeated separately for carotenoid- and melanin-based coloration. We distinguished carotenoid-based sexual monochromatism and dichromatism relying on colors that were yellow, orange and red as caused by carotenoids (see Tella *et al.* 2004, Olson & Owens 2005 for similar criteria). For melanin-based coloration we included all colors that were brown, black or reddish brown as typical for coloration based on phaeo- and eu-melanin (see also Gray 1996, Olson & Owens 2005).

Population size

Population sizes were obtained from Burfield and van Bommel (BirdLife International 2004), who reported the total number of breeding pairs in the Western Palaearctic west of the Ural Mountains, estimated in a consistent

way from national bird census programs in all countries. We used the mean of the minimum and maximum estimates in that source.

Range size and distribution limits

We estimated total geographical breeding range size as the area of the shape bounded by the greatest span of latitude and longitude of each species' entire breeding range, as published in Cramp and Perrins (1977–1994). We extracted the northernmost, southernmost, easternmost and westernmost distribution limits for the entire breeding range to the nearest 0.1 degree from the distribution maps in Cramp and Perrins (1977–1994). To take into account the curvature of the earth (which was assumed to be spherical), this area was estimated by the equation $Area = R^2 \times (Longitude_1 - Longitude_2) \times (\sin(Latitude_1) - \sin(Latitude_2))$ where R is the radius of the earth (6366.2 km) and latitude and longitude are expressed in radians. We used the northernmost and the southernmost distribution limits as estimates of distribution limits.

In widespread species Old and New World ranges were calculated separately and subsequently summed in order to obtain more precise estimate on range sizes at the global level. The method over-estimates the real geographical range, but the error should be random with respect to the variables under test. Estimates of area were strongly positively correlated with geographical range size as calculated by counting one-degree grid cells overlain on published distribution maps for a sample of 20 Palearctic and Nearctic bird species ($r = 0.87$, $P < 0.001$), and with range size as reported for a sample of 11 threatened species (Stattersfield & Capper 2000) ($r = 0.98$, $P < 0.001$, based on log-transformed data). Likewise, estimated

range sizes based on the equation above were strongly positively correlated with estimates based on image analysis of breeding distributions of birds in the Western Palearctic as reported in the electronic version of Cramp and Perrins (1977–1994) ($r = 0.52$, $N = 60$, $P < 0.001$, Møller *et al.* unpublished information).

The entire data set is provided in the appendix.

Comparative analyses

Analyses of comparative data based on species may provide misleading conclusions, if sister taxa are more similar with respect to the variables under investigation than randomly chosen species, and if species richness differs considerably between categories of species such as monochromatic and dichromatic species. We used statistically independent standardized linear contrasts (Felsenstein 1985), which controls for similarity among species due to common descent to test the predictions. Contrasts were calculated using the software of Purvis and Rambaut (1995), implemented in the computer program CAIC. Standardization of contrast values was checked by examination of absolute values of standardized contrasts versus their standard deviations (Garland 1992, Garland *et al.* 1992). Plotting the resulting contrasts against the variances of the corresponding nodes revealed that these transformations made the variables suitable for regression analyses.

We \log^{10} -transformed distribution area and population size before analyses.

Given that sexual dichromatism was a dichotomous variable we used the Brunch procedure in CAIC to identify all independent contrasts for nodes where transitions occurred in sexual dichromatism. At these

nodes positive contrasts in breeding distribution or population size imply that they vary in the same direction as sexual dichromatism. Using a t-test, we tested whether the mean of these contrasts differed from zero, as expected for correlated evolution of traits. To address problems of outlier contrasts, we analyzed the distribution of contrasts with a non-parametric test (Signed-rank test), which provided equivalent results to those obtained from parametric tests. As more breeding pairs may be present if the distribution range is larger, we also calculated population size while controlling for breeding distribution. We controlled statistically for this problem in a phylogenetically adjusted regression model of population size on breeding density. For this phylogenetically adjusted regression, using the Crunch procedure in CAIC, we regressed contrasts for the two continuous variables through the origin. Then, we fitted the slope to the raw species data, and calculated residuals from this regression line. These residuals, representing breeding density, were later analyzed by using the Brunch procedure to test for any effect of sexual dichromatism.

To determine the strength and direction of the relationship between dichromatism and distribution and population size, we estimated effect sizes (such as Cohen's sensu Cohen 1988), and the associated 95% confidence intervals (CI) for each particular phylogenetic relationship. We preferred reporting and focusing on effect sizes, instead of using Bonferroni correction and significance levels, because the latter approach has been criticized in the field of ecology and behavioural ecology due to mathematical and logical reasons (Perneger 1998, Moran 2003, Nakagawa 2004, Garamszegi 2006). Therefore, to balance between Type I and II errors, we followed the recent recommendations of

Nakagawa (2004), who emphasized the importance of unbiased reports of effect sizes. We used the software Comprehensive Meta Analysis (BioStat, 2000, <http://www.meta-analysis.com/>) to calculate effect sizes and corresponding confidence intervals (CI).

Comparative analyses rely on a phylogenetic hypothesis for identifying independent contrasts due to a transition from one kind of sexual coloration to another. We used a composite phylogeny created by using information from Sibley and Ahlquist (1990). This phylogeny for higher taxa was supplemented with information from other sources to resolve relationships between species (Randi *et al.* 1991a, b, Sheldon *et al.* 1992, Seibold *et al.* 1993, Sheldon & Winkler 1993, Suhonen *et al.* 1994, Wittmann *et al.* 1995, Blondel *et al.* 1996, Badyaev 1997, Leisler *et al.* 1997, Slikas 1997, Cibois & Pasquet 1999, Kimball *et al.* 1999, Svensson & Hedenström 1999, Voelker 1999, Johnson & Clayton 2000, Kennedy *et al.* 2000, Sheldon *et al.* 2000, Geffen & Yom-Tov 2001, Johnson *et al.* 2001, Møller *et al.* 2001, Barker *et al.* 2002, Dimcheff *et al.* 2002, Donne-Goussé *et al.* 2002, Broders *et al.* 2003, Riesing *et al.* 2003, Cibois & Cracraft 2004, Kruckenhauser *et al.* 2004, Thomas *et al.* 2004, Voelker & Spellman 2004, Lerner & Mindell 2005, Webb & Moore 2005). We applied branch lengths from the phylogeny of Sibley and Ahlquist (1990) for higher taxonomic levels. Within families the distance between different genera was set to $3.4 \Delta T_{50}H$ units, and between species within genera to $1.1 \Delta T_{50}H$ units (Sibley & Ahlquist 1990, Bennett & Owens 2002). The phylogenetic hypothesis for the 526 species used in the comparative analyses is available in "nexus" format as supplementary material.

Availability of information for different variables varied, and hence sample sizes

differed for the statistical tests. Although we had a huge sample size in terms of number of species, when using the Branch procedure, contrasts could be calculated for nodes only, where transition (from 0 to 1 or from 1 to 0) occurred in sexual dichromatism. These transition events are the focus of the current study.

Results

Analyzing transitions from monochromatic to dichromatic coloration, we failed to find strong effects for the relationship between range size and sexual dichromatism (Table 1). That was also the case when the analysis was restricted to melanin-based sexual dichromatism (Fig. 1, Table 1). In contrast, we

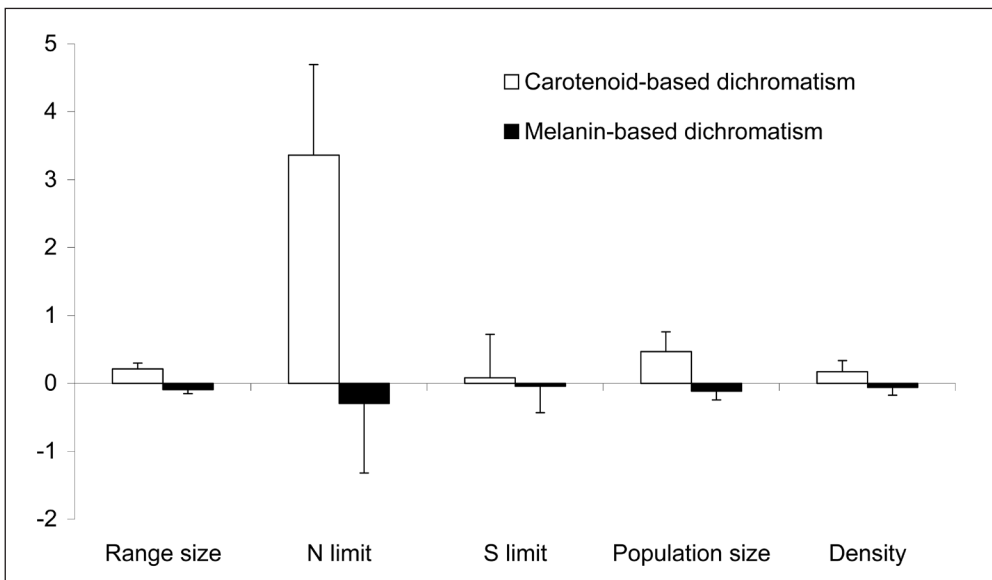
detected strong effects for a phylogenetic pattern, with range size being larger for taxa with sexually dichromatic carotenoid-based coloration compared to taxa with monochromatic coloration (Fig. 1, Table 1).

The association between carotenoid-based sexual dichromatism and range size was due to an increase in the northernmost distribution limit, whereas the southernmost distribution limit did not show strong differences between monochromatic and dichromatic species (Fig. 1, Table 1). In contrast, there was no such effect at a robust magnitude for melanin-based sexual dichromatism or for overall sexual dichromatism (Fig. 1, Table 1).

Effect sizes corresponding to overall population size and density were generally small, indicating that these traits did not appear to differ considerably between mono-

Fig. 1. Mean (SE) contrasts associated with carotenoid-based and melanin-based sexual dichromatism and range size, northernmost and southernmost distribution limit, population size, and density. Numbers are sample sizes.

1. ábra Az egyes változókra (elterjedési terület, legészakabb és legdélebb elterjedési határvonal, populációméret és denzitás) számolt átlagos (SE) standardizált kontrasztok eloszlása a különböző karotin és melanin alapú dikromatizmus csoportokban. A számok a mintaelemszámokat jelzik.



Variable	Effect size Cohen's d	Upper CI	Lower CI	t	P
Sexual dichromatism					
Range size	-0.420	-1.051	0.174	$t_{46} = -1.43$	0.161
Northernmost distribution limit	0.020	-0.572	0.614	$t_{47} = 0.07$	0.941
Southernmost distribution limit	-0.020	-0.614	0.572	$t_{47} = -0.06$	0.955
Population size	0.000	-0.614	0.614	$t_{44} = -0.02$	0.986
Density	-0.120	-0.749	0.497	$t_{43} = -0.39$	0.697
Melanin-based sexual dichromatism					
Range size	-0.431	-1.063	0.164	$t_{46} = -1.46$	0.151
Northernmost distribution limit	-0.085	-0.689	0.511	$t_{46} = -0.28$	0.778
Southernmost distribution limit	-0.028	-0.629	0.570	$t_{46} = -0.11$	0.916
Population size	-0.275	-0.916	0.339	$t_{43} = -0.90$	0.371
Density	-0.153	-0.784	0.464	$t_{43} = -0.50$	0.618
Carotenoid-based sexual dichromatism					
Range size	1.077	0.132	2.244	$t_{21} = 2.47$	0.022
Northernmost distribution limit	1.072	0.150	2.203	$t_{22} = 2.51$	0.020
Southernmost distribution limit	0.057	-0.843	0.967	$t_{22} = 0.13$	0.899
Population size	0.720	-0.220	1.815	$t_{20} = 1.61$	0.123
Density	0.466	-0.494	1.532	$t_{19} = 1.02$	0.323

Table 1. Effect sizes and associated 95% confidence intervals (CI) for the relationship between sexual dichromatism and population size and range size, respectively. Effect sizes are calculated for statistical analyses of standardized linear contrasts. Effect size conventions: $d = 0.20$ small effect, $d = 0.50$ medium effect, $d = 0.80$ large effects (Cohen 1988). Signs of effects indicate whether the evolutionary changes in dichromatism and population parameters occurred in parallel (+) or in opposite directions (-)

1. táblázat A vizsgált kapcsolatokra számolt statisztikai összefüggések erőssége (*effect size*) és az azokhoz tartozó 95%-os konfidencia intervallum. Az *effect size* metrikák a standardizált lineáris kontrasztokon alapuló statisztikai analízisekből erednek. *Effect size* konvenciók: $d = 0.20$ gyenge hatás, $d = 0.50$ közepes hatás, $d = 0.80$ erős hatás (Cohen 1988). Az előjelek azt mutatják, hogy az adott evolúciós változások a dikromatizmus változásával párhuzamosan (+) vagy ellentétes (-) irányban történnek

chromatic and dichromatic taxa, or between melanin-based and carotenoid-based sexual dichromatism (Fig. 1, Table 1).

Discussion

The present comparative study of sexual dichromatism in birds and population size and range size, respectively, did not show large

differences between monochromatic and dichromatic species. However, when we distinguished between carotenoid- and melanin-based coloration, there was evidence of clear relationships for carotenoid-based color. Species that were sexually dichromatic for carotenoid-based coloration had larger distributions, particularly due to more northern distribution limits compared to sexually monochromatic species. In contrast, there was no significant

difference between sexual monochromatism and dichromatism for melanin-based coloration. Population size and population densities were not found to differ significantly between sexual monochromatism and dichromatism, suggesting that species of birds with sexually dichromatic carotenoid-based coloration do not have significantly smaller population sizes or densities than sexually monochromatic species. These effects imply that species-specific effects of sexual coloration on range size depend on pigments involved in producing coloration.

Total breeding range size was larger when there was a transition from sexual monochromatism to sexual dichromatism for carotenoid-based coloration, but not when there was a similar transition for melanin-based coloration. This finding for carotenoid-based coloration was robust, as the corresponding effect size was larger than one (Table 1), indicating an explanatory power of 23% on the variance in carotenoid-based dichromatism (Table 1). This result is not consistent with the prediction that sexual selection imposes fitness costs on the average individual in a population (Andersson 1994) because that prediction should have produced a negative relationship. Given that the positive relationship only existed for species with sexual dichromatism for carotenoid-based coloration, but not for melanin-based coloration, it seems likely that the difference can be attributed to differences in the function of these two categories of pigments. Carotenoids play a major role in free-radical scavenging and immune regulation and stimulation (Ames 1983, Bendich 1989, Krinsky 1989, 1998, Chew 1996, Edge *et al.* 1997, Møller *et al.* 2001). Circulating levels of carotenoids in blood are positively related to the extent of sexual dichromatism in birds (Cassey *et al.* 2005,

Tella *et al.* 2004), suggesting that the level of physiological function of carotenoids is directly reflected by the external phenotype. The effect of carotenoids as antioxidants is important, but less important than that of vitamins A and E (Hartley & Kennedy 2004), whereas it is likely that the role of carotenoids in immune function is particularly important. Melanins may also act as free radical scavengers (McGinness *et al.* 1970, Rózanowska *et al.* 1999, Moreno & Møller 2006). In addition, melanin-based coloration may also be indicative of overall antioxidant status of the underlying tissue because only high concentrations of antioxidants allow melanocytes to migrate to feathers and soft tissue before depositing melanin (Bowers *et al.* 1994, 1999). We hypothesize that the different relationships between sexual dichromatism and range size for carotenoid-based and melanin-based coloration depend on these differences in physiological functions of the two categories of pigments.

We found strong evidence for a positive relationship between sexually dichromatic carotenoid-based coloration and northernmost distribution limits, but not southernmost distribution limits. Northernmost limits in the northern hemisphere are assumed to be determined by abiotic factors such as climate (Grinnell 1917, Orton 1920, Setchell 1920, Root 1988a, b), while southernmost distributions presumably are regulated by biotic interactions such as competition and parasitism (Connell 1961, MacArthur 1972, Davis *et al.* 1998, Sax *et al.* 2002). The association between northernmost distribution and carotenoid-based sexual dichromatism suggests that carotenoids may play an important role in coping with extreme abiotic conditions as found in the North.

We found no evidence of a significant association between sexual dichromatism

and population size. Given the association between carotenoid-based sexual dichromatism and range size, but the absence of an effect on population size, we would a priori expect a difference in population density between these two categories of species. However, that was not the case (Table 1), suggesting that density-dependent effects on competition, predation and parasitism would not differ between sexually dichromatic and monochromatic species with carotenoid-based coloration. Doherty *et al.* (2003) did not distinguish between carotenoid-based and melanin-based coloration in their analyses of sexual dichromatism and dynamics of bird populations in North America. It would be interesting to test if the population effects of sexual dichromatism differed between carotenoid-based and melanin-based sexual dichromatism as suggested by our study.

Given that the approach we used in this study is merely correlation, we cannot exclude that the results are due to some unmeasured variables. Several life history traits may affect both distribution ranges and the intensity of sexual selection, which would undermine the causal relationship between

the traits under investigation in this study. Therefore, the proposed relationships as they stand here may not be robust to alternative explanations. In this respect, we regard our study as a pioneer effort, and subsequent research may further investigate alternative hypotheses and additional confounders under the framework we followed here.

In conclusion, range size was larger and northernmost distribution limits extended to higher latitudes of sexually dichromatic birds with carotenoid-based coloration in the Western Palaearctic compared to their monochromatic relatives. There was no similar difference present for melanin-based sexual coloration, suggesting that differences in the physiological functions of these two categories of pigments are involved in determining the range size of birds.

Acknowledgments

Our research benefited from discussions with C. Spottiswoode. LZG was supported by the “Plan Nacional” program of the Spanish government (ref. no. CGL2009-10652 and CGL2009-09439).

References

- Ames, B. N. 1983. Dietary carcinogens and anticarcinogens: Oxygen radicals and degenerative diseases. – *Science* 221: 1256–1264.
- Andersson, M. 1994. Sexual selection. – Princeton University Press, Princeton
- Badyaev, A. V. 1997. Altitudinal variation in sexual dimorphism: a new pattern and alternative hypotheses. – *Behaviour Ecology* 8: 675–690.
- Barker, F. K., Barrowclough, G. F. & Groth, J. G. 2002. A phylogenetic hypothesis for passerine birds: taxonomic and biogeographic implications of an analysis of nuclear DNA sequence data. – *Proceedings of the Royal Society of London B* 269: 295–308.
- Bendich, A. 1989. Carotenoids and the immune response. – *Journal of Nutrition* 119: 112–115.
- Bennett, P. M. & Owens, I. P. F. 2002. Evolutionary ecology of birds. – Oxford University Press, Oxford
- BioStat. 2000. Comprehensive Meta-Analysis. – Englewood: BioStat.
- Blondel, J., Catzeflis, F. & Perret, P. 1996. Molecular phylogeny and the historical biogeography of the warblers of the genus *Sylvia* (Aves). – *Journal of Evolutionary Biology* 9: 871–891.
- Bowers, R. R., Lujan, J., Biboso, A., Kridel, S. & Varkey, C. 1994. Premature avian melanocyte death due to low antioxidant levels of protection – fowl model for vitiligo. – *Pigment Cell Research* 7: 409–418.
- Bowers, R. R., Nguyen, B., Buckner, S., Gonzalez, Y. & Ruiz, F. 1999. Role of antioxidants in the

- survival of normal and vitiliginous avian melanocytes. – *Cellular and Molecular Biology* 45: 1065–1074.
- Broders, O., Osborne, T. & Wink, M. 2003. A mtDNA phylogeny of bustards (family Otididae) based on nucleotide sequences of the cytochrome b-gene. – *Journal of Ornithology* 144: 176–185.
- BirdLife International 2004. Birds in Europe: population estimates, trends and conservation status. – Cambridge, UK: BirdLife International (BirdLife Conservation Series No. 12.)
- Cassey, P., Ewen, J. G., Boulton, R. L., Blackburn, T. M., Møller, A. P., Biard, C., Olson, V. & Karadas, F. 2005. Egg carotenoids in passerine birds introduced to New Zealand: Relations to ecological factors, integument coloration, and phylogeny. – *Functional Ecology* 19: 719–726.
- Chew, B. P. 1996. Importance of antioxidant vitamins in immunity and health in animals. – *Animal Feed Science and Technology* 59: 103–114.
- Cibois, A. & Cracraft, J. 2004. Assessing the passerine “Tapestry”: phylogenetic relationships of the Muscicapoidea inferred from nuclear DNA sequences. – *Molecular Phylogenetics and Evolution* 32: 264–273.
- Cibois, A. & Pasquet, E. 1999. Molecular analysis of the phylogeny of 11 genera of the Corvidae. – *Ibis* 141: 297–306.
- Cohen, J. 1988. Statistical power analysis for the behavioural sciences. – Hillsdale: Lawrence Erlbaum Associates
- Connell, J. H. 1961. The influence of interspecific competition and other factors on the distribution of the Barnacle *Chthamalus stellatus*. – *Ecology* 42: 710–723.
- Cramp, S. & Perrins, C. M. (eds.) 1977–1994. The birds of the Western Palearctic. – Vols. 1–9. Oxford University Press, Oxford
- Darwin, C. 1871. The descent of man, and selection in relation to sex. – London: John Murray
- Davis, A. J., Jenkinson, L. S., Lawton, J. H., Shorrocks, B. & Wood, S. 1998. Making mistakes when predicting shifts in species range in responses to global warming. – *Nature* 391: 783–786.
- Dimcheff, D. E., Drovetski, S. V. & Mindell, D. P. 2002. Phylogeny of Tetraoninae and other galliform birds using mitochondrial 12S and ND2 genes. – *Molecular Phylogenetics and Evolution* 24: 203–215.
- Doherty, P., Sorci, G., Royle, J. A., Hines, J. E., Nichols, J. D. & Boulinier, T. 2003. Sexual selection affects local extinction and turnover in bird communities. – *Proceedings of the National Academy of Sciences, USA* 100: 5858–5862.
- Donne-Goussé, C., Laudet, V. & Hänni, C. 2002. A molecular phylogeny of Anseriformes based on mitochondrial DNA analysis. – *Molecular Phylogenetics and Evolution* 23: 339–256.
- Edge, R., McGarvey, D. J. & Truscott, T. G. 1997. The carotenoids as antioxidants – a review. – *Journal of Photochemistry and Photobiology B* 41(3): 189–200.
- Felsenstein, J. 1985. Phylogenies and the comparative method. – *American Naturalist* 125: 1–15.
- Garamszegi, L. Zs. 2006. Along the way of forgetting Bonferroni correction: comparing effect sizes between variables. – *Behaviour Ecology* 17: 682–687.
- Garland, Jr. T. 1992. Rate tests for phenotypic evolution using phylogenetically independent contrasts. – *American Naturalist* 140: 509–519.
- Garland, Jr. T., Harvey, P. H. & Ives, A. R. 1992. Procedures for the analysis of comparative data using phylogenetically independent contrasts. – *American Naturalist* 41: 18–32.
- Geffen, E. & Yom-Tov, Y. 2001. Factors affecting the rates of intraspecific nest parasitism among Anseriformes and Galliformes. – *Animal Behaviour* 62: 1027–1038.
- Gontard-Danek, M-C. & Møller, A. P. 1999. The strength of sexual selection: a meta-analysis of bird studies. – *Behaviour Ecology* 10: 476–486.
- Gray, D. A. 1996. Carotenoids and sexual dichromatism in North American passerine birds. – *American Naturalist* 148: 453–480.
- Grinnell, J. 1917. Field tests of theories concerning distributional control. – *American Naturalist* 51: 115–128.
- Hartley, R. C. & Kennedy, M. W. 2004. Are carotenoids a red herring in sexual display? – *Trends in Ecology and Evolution* 19: 353–354.
- Johnson, K. P. & Clayton, D. H. 2000. Nuclear and mitochondrial genes contain similar phylogenetic signal for pigeons and doves (Aves: Columbiformes). – *Molecular Phylogenetics and Evolution* 14: 141–151.
- Johnson, K. P., De Kort, S., Dinwoodey, K., Mateman, A. C., Ten Cate, C., Lessells, C. M. & Clayton, D. H. 2001. A molecular phylogeny of the dove genera *Streptopelia* and *Columba*. – *Auk* 118: 874–887.
- Kennedy, M., Gray, R. D. & Spencer, H. G. 2000. The phylogenetic relationships of the shags and cormorants: Can sequence data resolve a disagreement between behavior and morphology? – *Molecular Phylogenetics and Evolution* 17: 345–359.
- Kimball, R. T., Braun, E. L., Zwartjes, P. W., Crowe, T. M. & Ligon, J. D. 1999. A molecular phylogeny of the pheasants and partridges suggests that these

- lineages are not monophyletic. – *Molecular Phylogenetics and Evolution* 11: 38–54.
- Krinsky, N. I. 1989. Antioxidant functions of carotenoids. – *Free Radical Biology and Medicine* 7: 617–635.
- Krinsky, N. I. 1998. The antioxidant and biological properties of the carotenoids. – *Annals of the New York Academy of Sciences* 854: 443–447.
- Krukenhauser, L., Haring, E., Pinsker, W., Riesing, M. J., Winkler, H., Wink, M. & Gamauf, A. 2004. Genetic vs. morphological differentiation of Old World buzzards (genus *Buteo*, Accipitridae). – *Zoologica Scripta* 33: 197–211.
- Leisler, B., Heidrich, P., Schulze-Hagen, K. & Wink, M. 1997. Taxonomy and phylogeny of Reed warblers (genus *Acrocephalus*) based on mtDNA sequences and morphology. – *Journal of Ornithology* 138: 469–496.
- Lerner, H. R. L. & Mindell, D. P. 2005. Phylogeny of eagles, Old World vultures, and other Accipitridae based on nuclear and mitochondrial DNA. – *Molecular Phylogenetics and Evolution* 37: 327–346.
- MacArthur, R. H. 1972. *Geographical ecology*. – New York: Harper and Row
- McGinness, J. E., Kono, R. & Moorhead, W. D. 1970. The melanosome: Cytoprotective or cytotoxic? – *Pigment Cell* 4: 270–276.
- McLain, D. K., Moulton, M. P. & Redfean, T. P. 1995. Sexual selection and the risk of extinction of introduced birds on oceanic islands. – *Oikos* 74: 27–34.
- McLain, D. K., Moulton, M. P. & Sanderson, J. G. 1999. Sexual selection and extinction: the fate of plumage-dimorphic and plumage-monomorphic birds introduced onto islands. – *Evolutionary Ecology Research* 1: 549–565.
- Moran, M. D. 2003. Arguments for rejecting the sequential Bonferroni in ecological studies. – *Oikos* 102: 403–405.
- Møller, A. P. & Birkhead, T. R. 1994. The evolution of plumage brightness in birds is related to extra-pair paternity. – *Evolution* 48: 1089–1100.
- Møller, A. P. & Ninni, P. 1998. Sperm competition and sexual selection: A meta-analysis of paternity studies of birds. – *Behavioral Ecology and Sociobiology* 43: 345–358.
- Møller, A. P., Biard, C., Blount, J. D., Houston, D. C., Ninni, P., Saino, N. & Surai, P. F. 2000. Carotenoid-dependent signals: Indicators of foraging efficiency, immunocompetence or detoxification ability? – *Poultry and Avian Biology Reviews* 11: 137–159.
- Møller, A. P., Merino, S., Brown, C. R. & Robertson, R. J. 2001. Immune defense and host sociality: a comparative study of swallows and martins. – *American Naturalist* 158: 136–145.
- Moreno, J. & Møller, A. P. 2006. Melanin deposition, oxidative stress and immunity: are melanin ornaments signalling antioxidant and immune capacity? – *Acta Zoologica Sinica* 52: 202–208.
- Nakagawa, S. 2004. A farewell to Bonferroni: the problems of low statistical power and publication bias. – *Behavioral Ecology* 15: 1044–1045.
- Olson, V. & Owens, I. P. F. 2005. Interspecific variation in the use of carotenoid-based coloration in birds: diet, life history and phylogeny. – *Journal of Evolutionary Biology* 18: 1534–1546.
- Orton, J. H. 1920. Sea-temperature, breeding, and distribution in marine animals. – *Journal of the Marine Biological Association* 12: 339–366.
- Perneger, T. V. 1998. What's wrong with Bonferroni adjustments. – *British Medical Journal* 316: 1236–1238.
- Petrie, M., Doums, C. & Møller, A. P. 1998. The degree of extra-pair paternity increases with genetic variability. – *Proceedings of the National Academy of Sciences, USA* 95: 9390–9395.
- Price, T. & Birch, G. L. 1996. Repeated evolution of sexual color dimorphism in passerine birds. – *Auk* 113: 842–848.
- Prinzing, A., Brändle, M., Pfeifer, R. & Brandl, R. 2002. Does sexual selection influence population trends in European birds? – *Evolutionary Ecology Research* 4: 49–60.
- Purvis, A. & Rambaut, A. 1995. Comparative analysis by independent contrasts (CAIC): An Apple Macintosh application for analysing comparative data. – *Computer Applications in the Biosciences* 11: 247–251.
- Randi, E., Fusco, G., Lorenzini, R. & Crowe, T. M. 1991a. Phylogenetic relationships and rates of allozyme evolution within the Phasianidae. – *Biochemical Systematics and Ecology* 19: 213–221.
- Randi, E., Fusco, G., Lorenzini, R. & Spina, F. 1991b. Allozyme divergence and phylogenetic relationships within the Strigiformes. – *Condor* 93: 295–301.
- Riesing, M. J., Krukenhauser, L., Gamauf, A. & Haring, E. 2003. Molecular phylogeny of the genus *Buteo* (Aves: Accipitridae) based on mitochondrial marker sequences. – *Molecular Phylogenetics and Evolution* 27: 328–342.
- Root, T. 1988a. Energy constraints on avian distributions and abundances. – *Ecology* 69: 330–339.
- Root, T. L. 1988b. Environmental factors associated with avian distributional boundaries. – *Journal of Biogeography* 15: 489–505.
- Rózanowska, M., Sarna, T., Land, E. J. & Truscott, T. G. 1999. Free radical scavenging properties of melanin interaction of eu- and pheo-melanin models with reducing and oxidising radicals. – *Free Radical Biology and Medicine* 26: 518–525.

- Sæther, B.-E., Engen, S., Lande, R., Møller, A. P., Bensch, S., Hasselquist, D., Leisler, B. & Beier, J. 2004. Time to extinction in relation to mating system and type of density regulation in populations with two sexes. – *Animal Ecology* 73: 925–934.
- Sax, D. F., Gaines, S. D. & Brown, J. H. 2002. Species invasions exceed extinctions on islands world-wide: a comparative study of plants and birds. – *American Naturalist* 160: 766–783.
- Seibold, I., Helbig, A. J. & Wink, M. 1993. Molecular systematics of falcons (family Falconidae). – *Naturwiss* 80: 87–90.
- Setchell, W. A. 1920. The temperature interval in the geographical distribution of marine algae. – *Science* 52: 187–190.
- Sheldon, F. H., Jones, C. E. & McCracken, K. G. 2000. Relative patterns and rates of evolution in heron nuclear and mitochondrial DNA. – *Molecular Biology and Evolution* 17: 437–450.
- Sheldon, F. H., Slikas, B., Kinnarney, M., Gill, F. B., Zhao, E. & Silverin, B. 1992. DNA-DNA hybridization evidence of phylogenetic relationships among major lineages of *Parus*. – *Auk* 109: 173–185.
- Sheldon, F. H. & Winkler, D. W. 1993. Intergeneric phylogenetic relationship of swallows estimated by DNA-DNA hybridization. – *Auk* 110: 798–824.
- Sibley, C. G. & Ahlquist, J. E. 1990. *Phylogeny and classification of birds: a study in molecular evolution*. – Yale University Press, New Haven and London.
- Slikas, B. 1997. Phylogeny of the avian family Ciconiidae (storks) based on cytochrome b sequences and DNA-DNA hybridization distances. – *Molecular Phylogenetics and Evolution* 8: 275–300.
- Sorci, G., Møller, A. P. & Clobert, J. 1998. Plumage dichromatism of birds predicts introduction success in New Zealand. – *Journal of Animal Ecology* 67: 263–269.
- Stattersfield, A. J. & Capper, D. R. 2000. *Threatened birds of the World*. – Lynx Ediciones, Barcelona.
- Suhonen, J., Alatalo, R. V. & Gustafsson, L. 1994. Evolution of foraging ecology in Fennoscandian tits (*Parus* spp.). – *Proceedings of the Royal Society of London B* 258: 127–131.
- Svensson, E. & Hedenström, A. 1999. A phylogenetic analysis of the evolution of moult strategies in Western Palearctic warblers (Aves: Sylviidae). – *Biological Journal of the Linnean Society* 67: 263–276.
- Tanaka, Y. 1996. Sexual selection enhances population extinction in a changing environment. – *Journal of Theoretical Biology* 180: 197–206.
- Tella, J. L., Figuerola, J., Negro, J. J., Blanco, G., Rodriguez-Estrella, R., Forero, M. G., Blazquez, M. C., Green, A. J. & Hiraldo, F. 2004. Ecological, morphological and phylogenetic correlates of interspecific variation in plasma carotenoid concentration in birds. – *Journal of Evolutionary Biology* 17: 156–164.
- Thomas, G. H., Wills, M. A. & Székely, T. 2004. A supertree approach to shorebird phylogeny. – *BMC Evolutionary Biology* 4: 28–45.
- Voelker, G. 1999. Dispersal, vicariance, and clocks: Historical biogeography and speciation in a cosmopolitan passerine genus (*Anthus*: Motacillidae). – *Evolution* 53: 1536–1552.
- Voelker, G. & Spellman, G. M. 2004. Nuclear and mitochondrial DNA evidence of polyphyly in the avian superfamily Muscicapoidea. – *Molecular Phylogenetics and Evolution* 30: 386–394.
- Webb, D. M. & Moore, W. S. 2005. A phylogenetic analysis of woodpeckers and their allies using 12S, Cyt b, and COI nucleotide sequences (class Aves; order Piciformes). – *Molecular Phylogenetics and Evolution* 36: 233–248.
- Wittmann, U., Heidrich, P., Wink, M. & Gwinner, E. 1995. Speciation in the Stonechat (*Saxicola torquata*) inferred from nucleotide-sequences of the cytochrome-b gene. – *Journal of Zoological Systematics and Evolutionary Research* 33: 293–303.

Appendix

Breeding range, northernmost and southernmost distribution limits, population size, and carotenoid- and melanin-based sexual monochromatism (0) and dichromatism (1) of breeding birds from the Western Palaearctic. See Material and methods for sources.

Melléklet

Elterjedési terület, legészakabb és legdélebb elterjedési határvonal, populációméret, denzitás, karotin és melanin alapú ivari monokromatizmus (0) és dikromatizmus (1) a nyugati Palearktikus zónában költő madárfajoknál. Forrásokért lásd a módszertani részt.

Species	Breeding range (km ²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
<i>Accipiter brevipes</i>	4986692	51.73	37.17	5150	1	0	1
<i>Accipiter gentilis</i>	85849275	70.31	35	185000	1	0	1
<i>Accipiter nisus</i>	59603419	70	35	395000	1	0	1
<i>Acrocephalus agricola</i>	15233035	56.36	35	675000	0	0	0
<i>Acrocephalus arundinaceus</i>	72532661	62.5	35	2200000	0	0	0
<i>Acrocephalus brevipennis</i>					0	0	0
<i>Acrocephalus dumetorum</i>	41083168	66.33	35	3500000	0	0	0
<i>Acrocephalus melanopogon</i>	20376220	49.8	35	225000	0	0	0
<i>Acrocephalus paludicola</i>	6111856	56.85	45.8	16000	0	0	0
<i>Acrocephalus palustris</i>	15087288	63.93	36.96	5000000	0	0	0
<i>Acrocephalus schoenobaenus</i>	22251413	70.63	37.17	5900000	0	0	0
<i>Acrocephalus scirpaceus</i>	28303507	64.64	35	3850000	0	0	0
<i>Acrocephalus stentoreus</i>	124263315	47.62	35		0	0	0
<i>Aegithalos caudatus</i>	58625883	70.33	35	8500000	0	0	0
<i>Aegolius funereus</i>	42058353	69	36.19	230000	0	0	0
<i>Aegypius monachus</i>	24840025	45.2	35	1850	0	0	0
<i>Alaemon alaudipes</i>	25932168	35.45	35		1	0	1
<i>Alauda arvensis</i>	52936591	71.16	35	60000000	0	0	0
<i>Alca torda</i>	22771938	76	42.38	600000	0	0	0
<i>Alcedo atthis</i>	129925253	60.71	35	119500	1	0	1
<i>Alectoris barbara</i>	6576177	41.17	35	13750	1	0	1
<i>Alectoris chukar</i>	20814845	50	35	1280000	1	0	1
<i>Alectoris graeca</i>	2380729	47.86	36.11	59000	1	0	1
<i>Alectoris rufa</i>	2543626	49.3	36.09	3250000	1	0	1
<i>Alle alle</i>	15305102	81.75	60	27500000	0	0	0
<i>Ammomanes cincturus</i>	21286928	35.46	35		0	0	0
<i>Ammomanes deserti</i>	31819081	36.81	35	0.165	0	0	0
<i>Anas acuta</i>	75773492	70.63	41.82	340000	1	0	1
<i>Anas clypeata</i>	69906543	68.17	36.96	190000	1	0	1
<i>Anas crecca</i>	80853819	70.31	35.83	1060000	1	0	1

Species	Breeding range (km ²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
<i>Anas penelope</i>	25639400	70.63	50	330000	1	0	1
<i>Anas platyrhynchos</i>	118317547	71.09	35	4200000	1	0	1
<i>Anas querquedula</i>	35857348	65.67	36.96	490000	1	0	1
<i>Anas strepera</i>	62053837	66.33	36.22	78000	1	0	1
<i>Anser albifrons</i>	23552110	75.27	57.5	67000	0	0	0
<i>Anser anser</i>	51496171	71.11	35	155000	0	0	0
<i>Anser brachyrhynchos</i>	3111481	80.14	63.93	59500	0	0	0
<i>Anser erythropus</i>	3989674	70.48	65.33	0.345	0	0	0
<i>Anser fabalis</i>	21544124	73.39	50.91	140000	0	0	0
<i>Anthreptes metallicus</i>	6584564	35	35		1	0	1
<i>Anthreptes platurus</i>	12075301	35	35		1	0	1
<i>Anthus berthelotii</i>	277684	35	35	60000	0	0	0
<i>Anthus campestris</i>	55732972	59.64	35	1450000	0	0	0
<i>Anthus cervinus</i>	20597343	71.17	52	2000000	0	1	1
<i>Anthus gustavi</i>	29537788	72.73	41.81	5500	0	0	0
<i>Anthus hodgsoni</i>	46149324	66	35	37500	0	0	0
<i>Anthus novaeseelandiae</i>	175722189	63.64	35		0	0	0
<i>Anthus pratensis</i>	19961896	71.17	40.83	11500000	0	0	0
<i>Anthus spinoletta</i>	58944503	75	35	1520000	0	0	0
<i>Anthus trivialis</i>	43026566	70.5	35	34500000	0	0	0
<i>Apus affinis</i>	131610822	37.17	35	1700	0	0	0
<i>Apus apus</i>	44557537	70	35	11950000	0	0	0
<i>Apus caffer</i>	54478159	37.61	35	0.13	0	0	0
<i>Apus melba</i>	87114000	48	35	235000	0	0	0
<i>Apus pallidus</i>	22582503	45.6	35	99500	0	0	0
<i>Apus unicolor</i>	287145	35	35	6250	0	0	0
<i>Aquila adalberti</i>	231533	41.25	37.22	0.177	0	0	0
<i>Aquila chrysaetos</i>	125774721	70.16	35	9700	0	0	0
<i>Aquila clanga</i>	22871979	65.33	39.09	0.955	0	0	0
<i>Aquila heliaca</i>	18651961	58.18	35	1125	0	0	0
<i>Aquila nipalensis</i>	22944219	52.38	35	12500	0	0	0
<i>Aquila pomarina</i>	30050752	59.73	35	16500	0	0	0
<i>Ardea cinerea</i>	174570058	68.67	35	250000	0	0	0
<i>Ardea purpurea</i>	155278503	53.14	35	35500	0	0	0
<i>Ardeola ralloides</i>	74517607	49.8	35	22500	0	0	0
<i>Arenaria interpres</i>	3182088	83.33	54.42	57500	0	0	0
<i>Asio flammeus</i>	178060822	70.47	38.91	119000	0	0	0
<i>Asio otus</i>	135709736	67	35		0	0	0
<i>Athene noctua</i>	73165616	57.64	35	930000	0	0	0
<i>Aythya ferina</i>	30655029	66	36.33	325000	1	0	1
<i>Aythya fuligula</i>	42202535	70.16	39	805000	1	0	1
<i>Aythya marila</i>	47354956	70.63	48.42	185000	1	0	1

Species	Breeding range (km ²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
<i>Aythya nyroca</i>	21338265	54.31	35	15000	1	0	1
<i>Bombycilla garrulus</i>	17809458	70.33	50.91	415000	1	1	1
<i>Bonasa bonasia</i>	35793103	69	38.18	2800000	1	0	1
<i>Botaurus stellaris</i>	145257380	61.73	35	44000	0	0	0
<i>Branta bernicla</i>	30327267	83.33	60	1650	0	0	0
<i>Branta leucopsis</i>	3110672	80	69.5	47500	0	0	0
<i>Bubo bubo</i>	94837463	69.67	35	28500	0	0	0
<i>Bubulcus ibis</i>	263346036	46.43	35	102000	0	0	0
<i>Bucanetes githagineus</i>	25504270	41.9	35	16000	0	1	1
<i>Bucanetes mongolicus</i>	16255585	50.9	35	2760	0	1	1
<i>Bucephala clangula</i>	48836042	70.31	44	540000	1	0	1
<i>Bucephala islandica</i>	27958081	66.32	39.26	0.55	1	0	1
<i>Bulweria bulwerii</i>	46406721	37.44	35	8000	0	0	0
<i>Burhinus oedicnemus</i>	62584206	54.31	35	62000	0	0	0
<i>Buteo buteo</i>	80859225	67.33	35	955000	0	0	0
<i>Buteo lagopus</i>	37620746	71.25	54.74	58500	0	0	0
<i>Buteo rufinus</i>	35371740	53.66	35	11850	0	0	0
<i>Calandrella brachydactyla</i>	33632687	52.69	35	10650000	1	0	1
<i>Calandrella rufescens</i>	31693703	50.96	35	2800000	0	0	0
<i>Calcarius lapponicus</i>	25955434	82	52.17	8400000	1	0	1
<i>Calidris alba</i>	19746119	83	62.86	37500	0	0	0
<i>Calidris alpina</i>	45810423	76.92	50.39	435000	0	0	0
<i>Calidris canutus</i>	8133350	83	61.82	22500	0	0	0
<i>Calidris maritima</i>	20683254	81.75	58.33	51500	0	0	0
<i>Calidris minuta</i>	4188252	76.41	67.27	253000	0	0	0
<i>Calidris temminckii</i>	10498393	71.25	60	252500	0	0	0
<i>Calonectris diomedea</i>	17232144	43.13	35	280000	0	0	0
<i>Caprimulgus europaeus</i>	39661425	63.93	35	735000	0	0	0
<i>Caprimulgus ruficollis</i>	2799658	42.92	35	65500	0	0	0
<i>Carduelis cannabina</i>	35387965	66	35	1900000	0	1	1
<i>Carduelis carduelis</i>	42127228	63.57	35	2050000	0	1	1
<i>Carduelis chloris</i>	33683563	70.31	35	2300000	1	1	1
<i>Carduelis flammea</i>	38772112	76	44.17	13900000	0	1	1
<i>Carduelis flavirostris</i>	42733807	71.25	35	465000	0	1	1
<i>Carduelis hornemanni</i>	39828582	82	56.36	132000	0	1	1
<i>Carduelis spinus</i>	48827224	70	35	14000000	1	1	1
<i>Carpodacus erythrinus</i>	56635635	67.67	35	4550000	0	1	1
<i>Carpodacus rubicilla</i>	13840898	51.82	35	7550	0	1	1
<i>Carpodacus synoicus</i>	8760831	38.1	35		0	1	1
<i>Carpospiza brachydactyla</i>	7427782	40	35		0	0	0
<i>Catharacta skua</i>	58138003	66.17	57.59	16000	0	0	0
<i>Cephus grylle</i>	69606205	81.75	42.86	215000	0	0	0

Species	Breeding range (km ²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
<i>Cercomela melanura</i>	4572806	35	35		0	0	0
<i>Cercotrichas galactotes</i>	42362514	47.62	35	64000	0	0	0
<i>Certhia brachydactyla</i>	11981649	55.74	35	6200000	0	0	0
<i>Certhia familiaris</i>	52296727	70.33	35	8350000	0	0	0
<i>Cettia cetti</i>	22945867	52.69	35	1100000	0	0	0
<i>Charadrius alexandrinus</i>	147247583	57.78	35	28500	0	0	0
<i>Charadrius dubius</i>	133225270	68.33	35	175000	1	0	1
<i>Charadrius hiaticula</i>	49403011	83.33	47.8	170000	1	0	1
<i>Charadrius morinellus</i>	39507955	73.28	42.08	26500	1	0	1
<i>Chersophilus duponti</i>	3171643	42.5	35	14000	0	0	0
<i>Chlamydotis undulata</i>	33255952	50.9	35	0.545	1	0	1
<i>Chlidonias hybrida</i>	153779188	51.92	35	64500	0	0	0
<i>Chlidonias leucopterus</i>	28419393	58.1	35	142000	0	0	0
<i>Chlidonias niger</i>	36059966	62.86	36.3	126500	0	0	0
<i>Ciconia ciconia</i>	38978214	59.73	35	200000	0	0	0
<i>Ciconia nigra</i>	156543483	63.08	35	9900	0	0	0
<i>Cinclus cinclus</i>	32649233	71.17	35.45	250000	0	0	0
<i>Circaetus gallicus</i>	51628656	60.36	35	10700	0	0	0
<i>Circus aeruginosus</i>	216191419	66	35	116500	1	0	1
<i>Circus cyaneus</i>	183998444	70.31	37.78	45500	1	0	1
<i>Circus macrourus</i>	9449299	55.91	39.39	0.755	1	0	1
<i>Circus pygargus</i>	24877885	60.71	35	50000	1	0	1
<i>Cisticola juncidis</i>	163848711	51.15	35	665000	0	0	0
<i>Clamator glandarius</i>	59374967	44.79	35	67500	0	0	0
<i>Clangula hyemalis</i>	49483737	82.22	51.71	720000	1	0	1
<i>Coccothraustes coccothraustes</i>	46328895	62.5	35	3300000	1	0	1
<i>Columba bollii</i>	19145	35	35	6250	0	0	0
<i>Columba junionae</i>	19145	35	35	1750	0	0	0
<i>Columba livia</i>	102111594	70	35	12150000	0	0	0
<i>Columba oenas</i>	31125952	65	35	625000	0	0	0
<i>Columba palumbus</i>	42222969	67.33	35	13000000	0	0	0
<i>Columba trocaz</i>	686	35	35	10550	0	0	0
<i>Coracias garrulus</i>	27947574	60.5	35	81500	0	0	0
<i>Corvus corax</i>	116351764	81	35	710000	0	0	0
<i>Corvus corone</i>	57070552	71.17	35	12000000	0	0	0
<i>Corvus frugilegus</i>	47448563	65.33	35	14000000	0	0	0
<i>Corvus monedula</i>	31652899	66.36	35	10100000	0	0	0
<i>Corvus ruficollis</i>	43735051	35.43	35		0	0	0
<i>Coturnix coturnix</i>	138134721	61.25	35	3750000	1	0	1
<i>Crex crex</i>	24591322	68	40.83	1650000	0	0	0
<i>Cuculus canorus</i>	79987916	70.47	35	6400000	0	0	0
<i>Cuculus saturatus</i>	82337843	50.45	35	375000	0	0	0

Species	Breeding range (km ²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
<i>Cursorius cursor</i>	44734680	40	35	0.36	0	0	0
<i>Cyanopica cyanus</i>	1669659	53.91	35	360000	0	0	0
<i>Cygnus columbianus</i>	24434047	72.38	55.45	10000	0	0	0
<i>Cygnus cygnus</i>	32594300	70	45.58	18500	0	0	0
<i>Cygnus olor</i>	30854760	62.41	35.92	103000	0	1	1
<i>Delichon urbica</i>	86520645	70.33	35	16950000	0	0	0
<i>Dendrocopos leucotos</i>	62001980	64.82	35	365000	0	1	1
<i>Dendrocopos major</i>	79065128	68.67	35	15000000	0	1	1
<i>Dendrocopos medius</i>	14754778	58.7	35	225000	0	1	1
<i>Dendrocopos minor</i>	45996198	70.63	35	775000	0	1	1
<i>Dendrocopos syriacus</i>	9427112	51.54	35	815000	0	1	1
<i>Dryocopus martius</i>	54009695	69.33	35	1070000	0	1	1
<i>Egretta alba</i>	256307748	50	35	17500	0	0	0
<i>Egretta garzetta</i>	180897650	49.08	35	81000	0	0	0
<i>Elanus caeruleus</i>	137707888	40.73	35	1405	0	0	0
<i>Emberiza aureola</i>	29976359	68.17	40	60000	1	1	1
<i>Emberiza bruniceps</i>	8171900	49.4	35	0.625	1	0	1
<i>Emberiza buchanani</i>	14835912	51.82	35	13200	1	0	1
<i>Emberiza caesia</i>	1979136	41.04	35	185000	1	0	1
<i>Emberiza cia</i>	21375695	51.82	35	2700000	1	0	1
<i>Emberiza cineracea</i>	470123	39.35	36.74	5200	1	0	1
<i>Emberiza cirius</i>	10526563	51.73	35	3600000	1	1	1
<i>Emberiza citrinella</i>	26826063	70.44	38.91	24500000	1	1	1
<i>Emberiza hortulana</i>	27681228	67.5	35	10600000	1	0	1
<i>Emberiza leucocephalos</i>	26353704	68.89	35	0.075	1	0	1
<i>Emberiza melanocephala</i>	10976526	47.8	35	6050000	1	1	1
<i>Emberiza pallasi</i>	17872157	71.43	45.22	115000	1	0	1
<i>Emberiza pusilla</i>	11732608	70.29	56.36	6500000	0	0	0
<i>Emberiza rustica</i>	19690540	68.67	50.9	8050000	1	0	1
<i>Emberiza schoeniclus</i>	55690608	71.18	35	6800000	1	0	1
<i>Emberiza striolata</i>	23851423	35.65	35		1	0	1
<i>Eremalauda dunni</i>	14348353	35	35		0	0	0
<i>Eremophila alpestris</i>	59723033	73.83	35	4400000	1	1	1
<i>Eremophila bilopha</i>	10175943	36.14	35		1	1	1
<i>Eremopterix nigriceps</i>	36523947	35	35		1	0	1
<i>Erithacus rubecula</i>	38251134	70	35	63000000	0	0	0
<i>Falco biarmicus</i>	61373886	44.38	35	0.69	1	0	1
<i>Falco cherrug</i>	28545648	59.09	35	0.45	1	0	1
<i>Falco columbarius</i>	60142061	71.09	42		1	0	1
<i>Falco eleonora</i>	6491767	43.13	35	6050	1	0	1
<i>Falco naumanni</i>	30494411	57.27	35	33500	1	0	1
<i>Falco peregrinus</i>	414461752	75.37	35	18500	1	0	1

Species	Breeding range (km ²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
<i>Falco rusticolus</i>	49680402	83.33	51.59	1800	1	0	1
<i>Falco subbuteo</i>	66368745	66.65	35	95500	1	0	1
<i>Falco tinnunculus</i>	202451931	70.63	35	415000	1	0	1
<i>Falco vespertinus</i>	16355333	64.11	42.92	32500	1	0	1
<i>Ficedula albicollis</i>	7661786	58.2	38.91	1900000	1	0	1
<i>Ficedula hypoleuca</i>	31222685	70.67	35	16000000	1	0	1
<i>Ficedula parva</i>	35801053	65	36.84	3900000	0	1	1
<i>Ficedula semitorquata</i>	3083761	45	36	34000	1	0	1
<i>Francolinus francolinus</i>	12586362	41.04	35	12000	1	0	1
<i>Fratercula arctica</i>	29362245	81	42.86	6500000	0	0	0
<i>Fringilla coelebs</i>	43879941	71.25	35	18500000	1	0	1
<i>Fringilla montifringilla</i>	21206352	71.25	50	17500000	1	0	1
<i>Fringilla teydea</i>	27935	35	35	1750	1	0	1
<i>Fulica atra</i>	236002248	66	35	1800000	0	0	0
<i>Fulica cristata</i>	47534848	37.17	35	0.08	0	0	0
<i>Fulmarus glacialis</i>	39811561	81.89	47.8	3600000	0	0	0
<i>Galerida cristata</i>	83319431	57.59	35	5600000	0	0	0
<i>Galerida theklae</i>	25706181	43.33	35	1800000	0	0	0
<i>Gallinago gallinago</i>	361621654	71.25	35	1415000	0	0	0
<i>Gallinago media</i>	12684637	70.63	47.27	116000	0	0	0
<i>Gallinago stenura</i>	13666038	71.43	50.91	1750	0	0	0
<i>Gallinula chloropus</i>	264037374	66		1300000	0	0	0
<i>Garrulus glandarius</i>	70688189	69.83	35	9500000	0	0	0
<i>Gavia arctica</i>	52965781	73.28	41.86	71500	0	0	0
<i>Gavia immer</i>	40351251	77.56	41.82	1500	0	0	0
<i>Gavia stellata</i>	66565237	82.19	44.39	62000	0	0	0
<i>Geronticus eremita</i>	3925676	37.07	35	15000	0	0	0
<i>Glareola normanni</i>	6039961	55.24	41.88	3800	0	0	0
<i>Glareola pratincola</i>	91406600	47.62	35	14000	0	0	0
<i>Glaucidium passerinum</i>	26060857	67.83	41.43	78500	0	0	0
<i>Grus grus</i>	34386572	69.67	36.52	92000	0	0	0
<i>Grus virgo</i>	13648596	52.73	36.36	22500	0	0	0
<i>Gypaetus barbatus</i>	105828315	49.09	35	0.805	0	0	0
<i>Gyps fulvus</i>	32363011	45.58	35	20000	0	0	0
<i>Haematopus ostralegus</i>	46951331	71.25	36.52	375000	0	0	0
<i>Haliaeetus albicilla</i>	76333390	70.87	35	5800	0	0	0
<i>Hieraaetus fasciatus</i>	154645128	45	35	1010	0	0	0
<i>Hieraaetus pennatus</i>	32217377	56.2	35	6650	0	0	0
<i>Himantopus himantopus</i>	333140845	53.33	35	50500	0	0	0
<i>Hippolais caligata</i>	24195303	63.57	35	55000	0	0	0
<i>Hippolais icterina</i>	21131336	70	36.84	5300000	0	0	0
<i>Hippolais languida</i>	7199961	44.76	35	25500	0	0	0

Species	Breeding range (km ²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
<i>Hippolais olivetorum</i>	1845761	44.17	35	17000	0	0	0
<i>Hippolais pallid</i>	34296106	48	35	5000000	0	0	0
<i>Hippolais polyglotta</i>	5102647	50.38	35	2000000	0	0	0
<i>Hirundo daurica</i>	123066917	55.45	35	265000	0	0	0
<i>Hirundo rustica</i>	79406477	70.38	35	26000000	1	0	1
<i>Histrionicus histrionicus</i>	62285997	72	36.3	7000	1	0	1
<i>Hydrobates pelagicus</i>	7903184	63.39	35.65	470000	0	0	0
<i>Hypocolius ampelinus</i>	2789769	36.36	35		1	0	1
<i>Irania gutturalis</i>	6786932	43.64	35	665000	1	0	1
<i>Iobrychus minutus</i>	159527643	59.91	35	90000	0	0	0
<i>Jynx torquilla</i>	44408201	69.5	35	940000	0	0	0
<i>Lagopus lagopus</i>	30623543	70.95	46.82	2700000	1	1	1
<i>Lagopus mutus</i>	107664662	83.33	35	915000	1	1	1
<i>Lanius collurio</i>	10296961	66.33	35	9650000	1	0	1
<i>Lanius excubitor</i>	114718756	70.62	35	325000	0	0	0
<i>Lanius isabellinus</i>	4992568	35	35		1	0	1
<i>Lanius minor</i>	22100451	55	35	1060000	1	0	1
<i>Lanius nubicus</i>	4100048	42.5	35	67500	1	0	1
<i>Lanius senator</i>	16564816	53.85	35	840000	1	0	1
<i>Larus argentatus</i>	58999039	71.25	47.4	1525000	0	0	0
<i>Larus armenicus</i>	424761	41.67	38.04	18500	0	0	0
<i>Larus audouinii</i>	2975151	43.33	35	18500	0	0	0
<i>Larus canus</i>	41869022	71.25	47.27	1045000	0	0	0
<i>Larus fuscus</i>	30475763	71.25	39.35	325000	0	0	0
<i>Larus genei</i>	14672467	35	35	46500	0	0	0
<i>Larus glaucooides</i>	4004503	76	60	65000	0	0	0
<i>Larus hyperboreus</i>	30987298	83.33	55.81	93500	0	0	0
<i>Larus ichthyaetus</i>	13106511	54.88	35	21500	0	0	0
<i>Larus marinus</i>	39787926	79.31	35.24	145000	0	0	0
<i>Larus melanocephalus</i>	5495226	54.31	38.7	220000	0	0	0
<i>Larus minutes</i>	17595446	68.25	47.27	41000	0	0	0
<i>Larus ridibundus</i>	43657220	68	36.67	1850000	0	0	0
<i>Limicola falcinellus</i>	7777206	70.16	60.36	15600	0	0	0
<i>Limosa lapponica</i>	5950810	70.31	63.53	4400	0	0	0
<i>Limosa limosa</i>	35726624	69.33	42.86	119500	0	0	0
<i>Locustella fluviatilis</i>	9966148	63.92	42.92	3250000	0	0	0
<i>Locustella lanceolata</i>	23056193	68.89	40.9	75000	0	0	0
<i>Locustella luscinioides</i>	30803045	59.07	35	665000	0	0	0
<i>Locustella naevia</i>	24571177	66	37.14	1520000	0	0	0
<i>Loxia curvirostra</i>	69460520	69.17	35	9400000	0	1	1
<i>Loxia leucoptera</i>	23590629	69.09	41.82	1950000	0	1	1
<i>Loxia pytyopsittacus</i>	5803577	69.67	53.85	680000	0	1	1

Species	Breeding range (km ²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
<i>Loxia scotica</i>	25456	57.96	56.67	0.775	0	1	1
<i>Lullula arborea</i>	17661277	62.14	35	2300000	0	0	0
<i>Luscinia calliope</i>	29042344	65.45	35	0.9	1	0	1
<i>Luscinia luscinia</i>	16872175	65	40	5300000	0	0	0
<i>Luscinia megarhynchos</i>	24692308	54.42	35	8100000	0	0	0
<i>Luscinia svecica</i>	63131559	71.17	35	6150000	1	0	1
<i>Lymnocyptes minimus</i>	12293323	70.31	55.56	44000	0	0	0
<i>Marmaronetta angustirostris</i>	14948033	46.67	35	0.695	1	0	1
<i>Melanitta fusca</i>	58407439	70.63	38.48	92500	1	0	1
<i>Melanitta nigra</i>	51699236	74.53	46.67	115000	1	0	1
<i>Melanocorypha bimaculata</i>	7727760	49.09	35	1600000	0	0	0
<i>Melanocorypha calandra</i>	23008892	51.9	35	17000000	0	0	0
<i>Melanocorypha leucoptera</i>	5775780	56	42.08	42500	1	0	1
<i>Melanocorypha yeltoniensis</i>	2256999	53.85	47.08	5500	1	0	1
<i>Mergus albellus</i>	23270884	69.67	47.04	6850	1	0	1
<i>Mergus merganser</i>	92714908	71.25	35	60500	1	0	1
<i>Mergus serrator</i>	77015015	73.2	40.91	96500	1	0	1
<i>Merops apiaster</i>	94226129	57.5	35	740000	0	0	0
<i>Miliaria calandra</i>	26299101	59.26	35	14950000	0	0	0
<i>Milvus migrans</i>	187366916	66.33	35	82000	0	0	0
<i>Milvus milvus</i>	27521009	59.44	35	22000	0	0	0
<i>Monticola saxatilis</i>	29812419	58.18	35	210000	1	0	1
<i>Monticola solitarius</i>	86047027	49.09	35	190000	1	0	1
<i>Montifringilla nivalis</i>	23133428	51.82	35	1060000	1	0	1
<i>Motacilla alba</i>	96194964	71.17	35	19500000	1	0	1
<i>Motacilla cinerea</i>	62906102	70.33	35	1170000	1	1	1
<i>Motacilla citreola</i>	38290500	76.36	35	365000	1	1	1
<i>Motacilla flava</i>	95983445	70.67	35	10950000	1	1	1
<i>Muscicapa striata</i>	39661505	70.5	35	18000000	0	0	0
<i>Nectarinia osea</i>	15450373	35	35		1	1	1
<i>Neophron percnopterus</i>	65013349	48.2	35	4550	0	0	0
<i>Netta rufina</i>	22710229	55	35	43000	1	0	1
<i>Nucifraga caryocatactes</i>	60803989	67.33	35	630000	0	0	0
<i>Numenius arquata</i>	25798929	70.63	42.71	290000	0	0	0
<i>Numenius phaeopus</i>	30525640	71.11	50	260000	0	0	0
<i>Nyctea scandiaca</i>	3804858	83.33	56.19	3450	1	0	1
<i>Nycticorax nycticorax</i>	285640786	51.92	35	75000	0	0	0
<i>Oceanodroma castro</i>	66294810	35	35	4250	0	0	0
<i>Oceanodroma leucorhoa</i>	51639528	67.83	40.95		0	0	0
<i>Oenanthe alboniger</i>	5816897	37.27	35		1	0	1
<i>Oenanthe deserti</i>	38780022	51.82	35	0.605	1	0	1
<i>Oenanthe finschii</i>	5174727	46	35	205000	1	0	1

Species	Breeding range (km ²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
<i>Oenanthe hispanica</i>	12349014	45.83	35	2350000	1	0	1
<i>Oenanthe isabellina</i>	21902794	51.15	35	4200000	1	0	1
<i>Oenanthe leucopyga</i>	17221802	36.36	35		1	0	1
<i>Oenanthe leucura</i>	6367277	42.92	35	10050	1	0	1
<i>Oenanthe lugens</i>	31194386	37.27	35		1	0	1
<i>Oenanthe moesta</i>	8121655	35.91	35		1	0	1
<i>Oenanthe monacha</i>	6365661	35.79	35		1	0	1
<i>Oenanthe oenanthe</i>	84869865	71.17	35	8800000	1	0	1
<i>Oenanthe pleschanka</i>	18344613	55	35	86000	1	0	1
<i>Oenanthe xanthorpyrma</i>	5332285	41.25	35	4550	1	0	1
<i>Oriolus oriolus</i>	37953232	62.86	35	5250000	1	1	1
<i>Otis tarda</i>	23244921	55.37	35.22	33500	1	0	1
<i>Otis tetrax</i>	13465079	50.98	35	210000	1	0	1
<i>Otus scops</i>	31441098	58.89	35	325000	0	0	0
<i>Oxyura leucocephala</i>	22254147	53.02	35	0.975	1	0	1
<i>Pandion haliaetus</i>	267565189	70	35	9300	0	0	0
<i>Panurus biarmicus</i>	29551674	59.26	35	360000	1	0	1
<i>Parus ater</i>	67081983	67.33	35	20500000	0	0	0
<i>Parus caeruleus</i>	22374181	67.33	35	32000000	1	1	1
<i>Parus cinctus</i>	26772997	70.67	51.11	1285000	0	0	0
<i>Parus cristatus</i>	17444546	67	36.09	9050000	0	0	0
<i>Parus cyaneus</i>	22366148	61	35.24	6950	1	0	1
<i>Parus lugubris</i>	7964820	46.88	35	875000	0	0	0
<i>Parus major</i>	124262164	70.67	35	68500000	1	1	1
<i>Parus montanus</i>	57808042	70.67	35	33000000	0	0	0
<i>Parus palustris</i>	60477603	65	35	4500000	0	0	0
<i>Passer domesticus</i>	92054602	71.25	35	96500000	1	0	1
<i>Passer hispaniolensis</i>	36844162	45.78	35	4500000	1	0	1
<i>Passer iagoensis</i>	72905	35	35		1	0	1
<i>Passer moabiticus</i>	2361777	38.48	35	1950	1	0	1
<i>Passer montanus</i>	127746779	70.1	35	3.70E+10	0	0	0
<i>Pelagodroma marina</i>	24137770	35	35	61000	0	0	0
<i>Pelecanus crispus</i>	19199362	48.88	35	1800	0	0	0
<i>Pelecanus onocrotalus</i>	112271620	46.8	35	4600	0	0	0
<i>Perdix perdix</i>	22588135	65.67	36.96	2350000	1	0	1
<i>Perisoreus infaustus</i>	27954938	70.33	43.64	525000	0	0	0
<i>Pernis apivorus</i>	24169813	66.75	35	135000	0	0	0
<i>Petronia brachydactyla</i>				12500	0	1	1
<i>Petronia petronia</i>	32839062	52.73	35	2750000	0	1	1
<i>Petronia xanthocollis</i>	17106070	38.04	35	1250	0	1	1
<i>Phalacrocorax aristotelis</i>	22003193	71.27	35	92000	0	0	0
<i>Phalacrocorax carbo</i>	256994846	71.27	35	340000	0	0	0

Species	Breeding range (km ²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
<i>Phalacrocorax pygmaeus</i>	8293493	46.8	35	33500	0	0	0
<i>Phalaropus fulicarius</i>	23272003	79.58	65	1045	1	0	1
<i>Phalaropus lobatus</i>	40516880	71.25	56.48	152500	1	0	1
<i>Philomachus pugnax</i>	21967652	71.25	50	355000	1	0	1
<i>Phoenicopterus ruber</i>	94427924	52.38	35	57000	0	0	0
<i>Phoenicurus erythrogaster</i>	18962799	58.18	35	4050	1	0	1
<i>Phoenicurus erythronotus</i>	5412343	53.04	36		1	0	1
<i>Phoenicurus moussieri</i>	1885549	37.17	35		1	0	1
<i>Phoenicurus ochruros</i>	35108160	60.36	35	6400000	1	0	1
<i>Phoenicurus phoenicurus</i>	39333278	70.5	35	11400000	1	0	1
<i>Phylloscopus bonelli</i>	11145975	51.92	35	2450000	0	0	0
<i>Phylloscopus borealis</i>	53980390	70.29	35	6250000	0	0	0
<i>Phylloscopus canariensis</i>				60000	0	0	0
<i>Phylloscopus collybita</i>	57078465	70.29	35	45445000	0	0	0
<i>Phylloscopus inornatus</i>	36998188	67.67	35	20000	0	0	0
<i>Phylloscopus nitidus</i>	9042071	45	35		0	0	0
<i>Phylloscopus sibilatrix</i>	20758794	68.33	38.91	18000000	0	0	0
<i>Phylloscopus sindianus</i>	5398213	43.54	35	195500	0	0	0
<i>Phylloscopus trochiloides</i>	33405236	65.33	35	13500000	0	0	0
<i>Phylloscopus trochilus</i>	34702775	71.18	43.13	78000000	0	0	0
<i>Pica pica</i>	125873841	71.25	35	13250000	0	0	0
<i>Picoides tridactylus</i>	71576575	60.63	35	725000	0	1	1
<i>Picus canus</i>	102686392	64.29	35	250000	0	1	1
<i>Picus viridis</i>	15764792	66	35	945000	0	1	1
<i>Pinicola enucleator</i>	46544352	70.31	35	200000	0	1	1
<i>Platalea leucorodia</i>	72330620	53.73	35	11950	0	0	0
<i>Plectrophenax nivalis</i>	25494753	83	53.64	1190000	1	0	1
<i>Plegadis falcinellus</i>	170666899	51.71	35	19000	0	0	0
<i>Pluvialis apricaria</i>	15646226	71.25	50.69	600000	0	0	0
<i>Pluvialis squatarola</i>	21151630	77.27	58.75	6550	0	0	0
<i>Podiceps auritus</i>	47747524	69.67	44.21	8650	0	0	0
<i>Podiceps cristatus</i>	216751787	66	35	375000	0	0	0
<i>Podiceps griseigena</i>	50645661	67.67	37.07	44000	0	0	0
<i>Podiceps nigricollis</i>	143944998	58.52	35	74500	0	0	0
<i>Polysticta stelleri</i>	7467798	72.73	59	7700	1	0	1
<i>Porphyrio porphyrio</i>	203357685	48	35	24000	0	0	0
<i>Porzana parva</i>	17089892	59.17	36.78	100500	0	0	0
<i>Porzana porzana</i>	30534300	65	35	190000	0	0	0
<i>Porzana pusilla</i>	209099178	57.87	35	1980	0	0	0
<i>Prinia gracilis</i>	26799729	37.39	35		0	0	0
<i>Prunella atrogularis</i>	7555104	66.17	38.88	2000	0	0	0
<i>Prunella collaris</i>	43136324	57.27	35	140000	0	0	0

Species	Breeding range (km ²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
<i>Prunella modularis</i>	18168515	70.67	36.84	19000000	0	0	0
<i>Prunella montanella</i>	15909261	72.38	50.91	0.3	0	0	0
<i>Prunella ocularis</i>	4561671	43.54	35	22000	0	0	0
<i>Pterocles alchata</i>	16583502	48	35	15500	1	0	1
<i>Pterocles orientalis</i>	23634655	51	35	45000	1	0	1
<i>Pterodroma feae</i>				0.215	0	0	0
<i>Pterodroma madeira</i>				0.035	0	0	0
<i>Ptyonoprogne rupestris</i>	50741090	50	35	245000	0	0	0
<i>Puffinus assimilis</i>	10870919	38.04	35	6050	0	0	0
<i>Puffinus mauretanicus</i>	306058	40	35.43	1850	0	0	0
<i>Puffinus puffinus</i>	7809271	63.39	35	370000	0	0	0
<i>Puffinus yelkouan</i>	1757944	44.17	35.22	23000	0	0	0
<i>Pycnonotus leucogenys</i>	8950084	35.43	35		0	0	0
<i>Pyrrhocorax graculus</i>	25554494	51.82	35	220000	0	0	0
<i>Pyrrhocorax pyrrhocorax</i>	71209934	56.11	35	76500	0	0	0
<i>Pyrrhula murina</i>	0	38.44	38.4	0.24	0	0	0
<i>Pyrrhula pyrrhula</i>	48033841	70.31	35	10650000	0	1	1
<i>Rallus aquaticus</i>	61237985	66.17	35	250000	0	0	0
<i>Recurvirostra avosetta</i>		58.89	35	47500	0	0	0
<i>Regulus ignicapillus</i>	11619889	56.3	35	5000000	0	1	1
<i>Regulus regulus</i>	60111318	70.29	35	27000000	0	1	1
<i>Regulus teneriffae</i>				15000	0	1	1
<i>Remiz pendulinus</i>	34607944	60.36	35	315000	1	0	1
<i>Rhamphocoris clotbey</i>	7281554	35	35		1	0	1
<i>Rhodopechys obsoleta</i>	21566986	50	35	4500	0	1	1
<i>Rhodopechys sanguinea</i>	18028831	48.18	35	605000	0	1	1
<i>Riparia riparia</i>	71056288	70.5	35	7450000	0	0	0
<i>Rissa tridactyla</i>	87063032	82	39	2550000	0	0	0
<i>Saxicola dacotiae</i>	824	35	35	1300	1	0	1
<i>Saxicola rubetra</i>	23515354	70	37.17	7700000	1	0	1
<i>Saxicola torquata</i>	191983539	66.65	35	3300000	1	0	1
<i>Scolopax rusticola</i>	61514142	70.16	35	4200000	0	0	0
<i>Scotocerca inquieta</i>	30552038	45.71	35		0	0	0
<i>Serinus canaria</i>	1169421	39.2	35	60000	0	1	1
<i>Serinus citronella</i>	1979731	49.17	38.7	337000	0	1	1
<i>Serinus pusillus</i>	12794168	49.09	35	550000	0	1	1
<i>Serinus serinus</i>	17598255	59.81	35	14150000	0	1	1
<i>Serinus syriacus</i>	14323	35	35		0	0	1
<i>Sitta europaea</i>	95378950	67	35	13250000	1	0	1
<i>Sitta krueperi</i>	1668810	44.38	36.09	125000	1	0	1
<i>Sitta ledanti</i>	1310	36.74	36.3		1	0	1
<i>Sitta neumayeri</i>	9963123	45.6	35	4050000	0	0	0

Species	Breeding range (km ²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
<i>Sitta tephronota</i>	7093661	42.73	35	61000	0	0	0
<i>Sitta whiteheadi</i>	3650	42.5	41.67	3000	1	0	1
<i>Somateria mollissima</i>	30201352	80.83	42.86	1020000	1	0	1
<i>Somateria spectabilis</i>	16888563	82.22	66.67	41500	1	0	1
<i>Stercorarius longicaudus</i>	39653124	78.89	51.58	45000	0	0	0
<i>Stercorarius parasiticus</i>	46690152	81.75	51.11	90000	0	0	0
<i>Stercorarius pomarinus</i>	17351156	77.03	65.45	35000	0	0	0
<i>Sterna albifrons</i>	206217797	65.94	35	45000	0	0	0
<i>Sterna caspia</i>	242849556	65.94	35	7000	0	0	0
<i>Sterna dougallii</i>	146908338	56.11	35	1850	0	0	0
<i>Sterna hirundo</i>	137032125	71.25	35	420000	0	0	0
<i>Sterna nilotica</i>	82533374	58.83	35	17000	0	0	0
<i>Sterna paradisaea</i>	66381992	81.75	50.59	700000	0	0	0
<i>Sterna sandvichensis</i>	55524756	59.26	39.5	106000	0	0	0
<i>Streptopelia decaocto</i>	84393908	69.67	35	7850000	0	0	0
<i>Streptopelia senegalensis</i>	97574458	45.37	35	135500	0	0	0
<i>Streptopelia turtur</i>	49092131	63.84	35	5350000	0	0	0
<i>Strix aluco</i>	55876079	65	35	740000	0	0	0
<i>Strix nebulosa</i>	41488904	68.83	45.5	4400	0	0	0
<i>Strix uralensis</i>	41750956	68.67	35	96500	0	0	0
<i>Sturnus roseus</i>	11585863	54.55	35.79	134000	1	1	1
<i>Sturnus unicolor</i>	3716312	43.75	35	2600000	1	0	1
<i>Sturnus vulgaris</i>	57229673	71.25	35	39500000	1	1	1
<i>Sula bassana</i>	15246153	70.78	46	305000	0	0	0
<i>Surnia ulula</i>	54632344	70	38.95	23600	0	0	0
<i>Sylvia atricapilla</i>	49004644	70.1	35	37000000	1	0	1
<i>Sylvia borin</i>	24656982	70.31	36.74	24000000	0	0	0
<i>Sylvia cantillans</i>	7240806	46	35	2300000	1	0	1
<i>Sylvia communis</i>	34153491	69.33	35	19500000	1	0	1
<i>Sylvia conspicillata</i>	20177769	46.2	35	310000	1	0	1
<i>Sylvia curruca</i>	44818321	69.67	35	6300000	0	0	0
<i>Sylvia deserticola</i>	1607574	37.61	35		1	0	1
<i>Sylvia hortensis</i>	16088720	47.4	35	325000	1	0	1
<i>Sylvia leucomelaena</i>	5398066	35	35		1	0	1
<i>Sylvia melanocephala</i>	12182597	46	35	5600000	1	0	1
<i>Sylvia melanothorax</i>	24440	35.65	35	105000	1	0	1
<i>Sylvia mystacea</i>	5804712	46.88	35	96500	1	0	1
<i>Sylvia nana</i>	42836194	49.17	35	3000	0	0	0
<i>Sylvia nisoria</i>	17364578	62.5	38.95	730000	1	0	1
<i>Sylvia rueppelli</i>	941133	41.04	35	405000	1	0	1
<i>Sylvia sarda</i>	674571	42.93	36.52	52000	1	0	1
<i>Sylvia undata</i>	4095075	51.35	35	2800000	1	0	1

Species	Breeding range (km ²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
<i>Tachybaptus ruficollis</i>	170152125	60.18	35	134500	0	0	0
<i>Tadorna ferruginea</i>	38145652	57.14	35	26000	1	1	1
<i>Tadorna tadorna</i>	38534754	66.17	35	53500	1	1	1
<i>Tarsiger cyaneus</i>	53194293	68	35	15500	1	0	1
<i>Tetrao mlokosiewiczzi</i>	517607	45	38.78	84500	1	1	1
<i>Tetrao tetrix</i>	29140443	70	40.93	2850000	1	1	1
<i>Tetrao urogallus</i>	23208757	30.31	41.15	880000	1	1	1
<i>Tetraogallus caspius</i>	1994433	40.83	35	5750	1	0	1
<i>Tetraogallus caucasicus</i>	251888	43.75	40.52	49500	1	0	1
<i>Tichodroma muraria</i>	26203595	49.09	35	69000	1	1	1
<i>Tringa cinereus</i>	21277895	72.73	49	48000	0	0	0
<i>Tringa erythropus</i>	5342798	70.31	63.75	30500	0	0	0
<i>Tringa glareola</i>	22194411	70.78	50	775000	0	0	0
<i>Tringa hypoleucos</i>	56601323	71.25	35	1160000	0	0	0
<i>Tringa nebularia</i>	22863287	70.31	50	117500	0	0	0
<i>Tringa ochropus</i>	31097993	68.83	40	565000	0	0	0
<i>Tringa stagnatilis</i>	13130763	60.91	44.38	22000	0	0	0
<i>Tringa totanus</i>	52792516	71.09	35	445000	0	0	0
<i>Troglodytes troglodytes</i>	85810285	69.33	35	31500000	0	0	0
<i>Turdoides altirostris</i>	225670	35	35		0	0	0
<i>Turdoides squamiceps</i>	5803178	35	35		0	0	0
<i>Turdus iliacus</i>	25824771	71.17	49	18500000	0	0	0
<i>Turdus merula</i>	86850440	71.17	35	61000000	1	1	1
<i>Turdus philomelos</i>	30851069	70.33	36	28000000	0	0	0
<i>Turdus pilaris</i>	24506818	71.17	44.58	19000000	0	0	0
<i>Turdus ruficollis</i>	16765713	66.65	36	12500	1	0	1
<i>Turdus torquatus</i>	17793028	71.17	36.09	490000	1	0	1
<i>Turdus viscivorus</i>	33724781	69	35	5200000	0	0	0
<i>Tyto alba</i>	419862587	57.45	35	165000	0	0	0
<i>Upupa epops</i>	161518909	60	35	1295000	1	0	1
<i>Uria aalge</i>	54241213	78.89	39.35		0	0	0
<i>Uria lomvia</i>	52613330	81	46.83	2200000	0	0	0
<i>Vanellus vanellus</i>	37072931	70.16	35.79	2250000	1	0	1
<i>Zoothera dauma</i>	78736278	60.71	35	62500	0	0	0