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Sexual selection, range size and population size

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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 Palaearctic. 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 kifejlesztése és fenntartása bizonyos költségekkel terheltek, melyek visszahatnak a rátermettségre az erősen ivari szelekció alatt álló fajoknál. A rátermettségben megmutatkozó 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 következtetünk, 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. Összegzéskeppen 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

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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 Palaearctic 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 Palaearctic 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 Brunch 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 dischromatic 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.
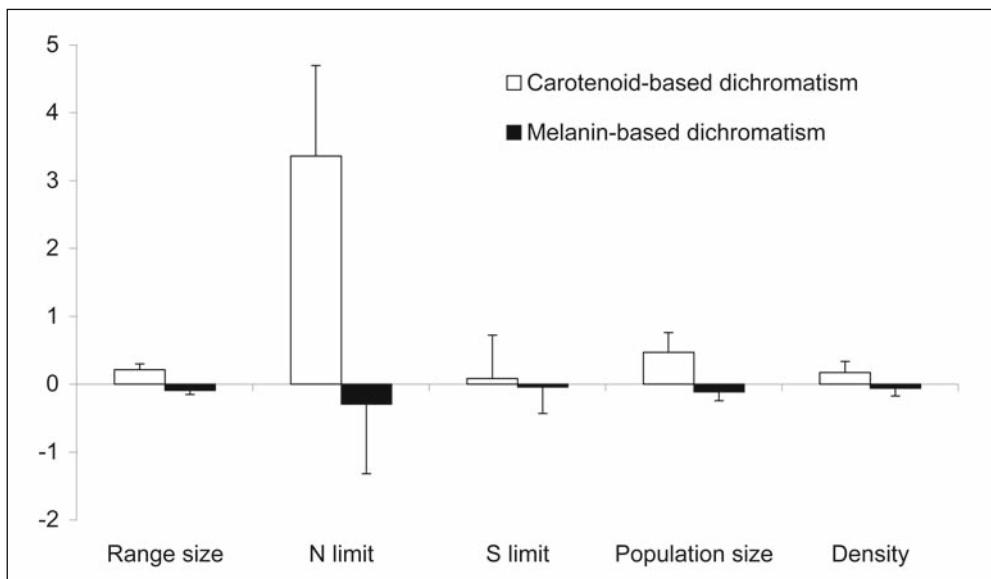
Variable	Effect size Cohen's d	Upper CI	Lower CI	t	P
Sexual dichromatism					
Range size	−0.420	−1.051	0.174	$t_{46} = -1.43$	0.161
Northernmost distribution limit	0.020	−0.572	0.614	$t_{47} = 0.07$	0.941
Southernmost distribution limit	−0.020	−0.614	0.572	$t_{47} = -0.06$	0.955
Population size	0.000	−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

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

Species	Breeding range (km²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
Anas penelope	25639400	70.63	50	330000	1	0	1
Anas platyrhynchos	118317547	71.09	35	4200000	1	0	1
Anas querquedula	35857348	65.67	36.96	490000	1	0	1
Anas strepera	62053837	66.33	36.22	78000	1	0	1
Anser albifrons	23552110	75.27	57.5	67000	0	0	0
Anser anser	51496171	71.11	35	155000	0	0	0
Anser brachyrhynchos	3111481	80.14	63.93	59500	0	0	0
Anser erythropus	3989674	70.48	65.33	0.345	0	0	0
Anser fabalis	21544124	73.39	50.91	140000	0	0	0
Anthreptes metallicus	6584564	35	35		1	0	1
Anthreptes platurus	12075301	35	35		1	0	1
Anthus berthelotii	277684	35	35	60000	0	0	0
Anthus campestris	55732972	59.64	35	1450000	0	0	0
Anthus cervinus	20597343	71.17	52	2000000	0	1	1
Anthus gustavi	29537788	72.73	41.81	5500	0	0	0
Anthus hodgsoni	46149324	66	35	37500	0	0	0
Anthus novaeseelandiae	175722189	63.64	35		0	0	0
Anthus pratensis	19961896	71.17	40.83	11500000	0	0	0
Anthus spinoletta	58944503	75	35	1520000	0	0	0
Anthus trivialis	43026566	70.5	35	34500000	0	0	0
Apus affinis	131610822	37.17	35	1700	0	0	0
Apus apus	44557537	70	35	11950000	0	0	0
Apus caffer	54478159	37.61	35	0.13	0	0	0
Apus melba	87114000	48	35	235000	0	0	0
Apus pallidus	22582503	45.6	35	99500	0	0	0
Apus unicolor	287145	35	35	6250	0	0	0
Aquila adalberti	231533	41.25	37.22	0.177	0	0	0
Aquila chrysaetos	125774721	70.16	35	9700	0	0	0
Aquila clanga	22871979	65.33	39.09	0.955	0	0	0
Aquila heliaca	18651961	58.18	35	1125	0	0	0
Aquila nipalensis	22944219	52.38	35	12500	0	0	0
Aquila pomarina	30050752	59.73	35	16500	0	0	0
Ardea cinerea	174570058	68.67	35	250000	0	0	0
Ardea purpurea	155278503	53.14	35	35500	0	0	0
Ardeola ralloides	74517607	49.8	35	22500	0	0	0
Arenaria interpres	3182088	83.33	54.42	57500	0	0	0
Asio flammeus	178060822	70.47	38.91	119000	0	0	0
Asio otus	135709736	67	35		0	0	0
Athene noctua	73165616	57.64	35	930000	0	0	0
Aythya ferina	30655029	66	36.33	325000	1	0	1
Aythya fuligula	42202535	70.16	39	805000	1	0	1
Aythya marila	47354956	70.63	48.42	185000	1	0	1

Species	Breeding range (km²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
Aythya nyroca	21338265	54.31	35	15000	1	0	1
Bombycilla garrulus	17809458	70.33	50.91	415000	1	1	1
Bonasa bonasia	35793103	69	38.18	2800000	1	0	1
Botaurus stellaris	145257380	61.73	35	44000	0	0	0
Branta bernicla	30327267	83.33	60	1650	0	0	0
Branta leucopsis	3110672	80	69.5	47500	0	0	0
Bubo bubo	94837463	69.67	35	28500	0	0	0
Bubulcus ibis	263346036	46.43	35	102000	0	0	0
Bucanetes githagineus	25504270	41.9	35	16000	0	1	1
Bucanetes mongolicus	16255585	50.9	35	2760	0	1	1
Bucephala clangula	48836042	70.31	44	540000	1	0	1
Bucephala islandica	27958081	66.32	39.26	0.55	1	0	1
Bulweria bulwerii	46406721	37.44	35	8000	0	0	0
Burhinus oedicnemus	62584206	54.31	35	62000	0	0	0
Buteo buteo	80859225	67.33	35	955000	0	0	0
Buteo lagopus	37620746	71.25	54.74	58500	0	0	0
Buteo rufinus	35371740	53.66	35	11850	0	0	0
Calandrella brachydactyla	33632687	52.69	35	10650000	1	0	1
Calandrella rufescens	31693703	50.96	35	2800000	0	0	0
Calcarius lapponicus	25955434	82	52.17	8400000	1	0	1
Calidris alba	19746119	83	62.86	37500	0	0	0
Calidris alpina	45810423	76.92	50.39	435000	0	0	0
Calidris canutus	8133350	83	61.82	22500	0	0	0
Calidris maritima	20683254	81.75	58.33	51500	0	0	0
Calidris minuta	4188252	76.41	67.27	253000	0	0	0
Calidris temminckii	10498393	71.25	60	252500	0	0	0
Calonectris diomedea	17232144	43.13	35	280000	0	0	0
Caprimulgus europaeus	39661425	63.93	35	735000	0	0	0
Caprimulgus ruficollis	2799658	42.92	35	65500	0	0	0
Carduelis cannabina	35387965	66	35	19000000	0	1	1
Carduelis carduelis	42127228	63.57	35	20500000	0	1	1
Carduelis chloris	33683563	70.31	35	23000000	1	1	1
Carduelis flammea	38772112	76	44.17	13900000	0	1	1
Carduelis flavirostris	42733807	71.25	35	465000	0	1	1
Carduelis hornemanni	39828582	82	56.36	132000	0	1	1
Carduelis spinus	48827224	70	35	14000000	1	1	1
Carpodacus erythrinus	56635635	67.67	35	4550000	0	1	1
Carpodacus rubicilla	13840898	51.82	35	7550	0	1	1
Carpodacus synoicus	8760831	38.1	35		0	1	1
Carpospiza brachydactyla	7427782	40	35		0	0	0
Catharacta skua	58138003	66.17	57.59	16000	0	0	0
Cepphus grylle	69606205	81.75	42.86	215000	0	0	0

Species	Breeding range (km²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
Cercomela melanura	4572806	35	35		0	0	0
Cercotrichas galactotes	42362514	47.62	35	64000	0	0	0
Certhia brachydactyla	11981649	55.74	35	6200000	0	0	0
Certhia familiaris	52296727	70.33	35	8350000	0	0	0
Cettia cetti	22945867	52.69	35	1100000	0	0	0
Charadrius alexandrinus	147247583	57.78	35	28500	0	0	0
Charadrius dubius	133225270	68.33	35	175000	1	0	1
Charadrius hiaticula	49403011	83.33	47.8	170000	1	0	1
Charadrius morinellus	39507955	73.28	42.08	26500	1	0	1
Chersophilus duponti	3171643	42.5	35	14000	0	0	0
Chlamydotis undulata	33255952	50.9	35	0.545	1	0	1
Chlidonias hybrida	153779188	51.92	35	64500	0	0	0
Chlidonias leucopterus	28419393	58.1	35	142000	0	0	0
Chlidonias niger	36059966	62.86	36.3	126500	0	0	0
Ciconia ciconia	38978214	59.73	35	200000	0	0	0
Ciconia nigra	156543383	63.08	35	9900	0	0	0
Cinclus cinclus	32649233	71.17	35.45	250000	0	0	0
Circaetus gallicus	51628656	60.36	35	10700	0	0	0
Circus aeruginosus	216191419	66	35	116500	1	0	1
Circus cyaneus	183998444	70.31	37.78	45500	1	0	1
Circus macrourus	9449299	55.91	39.39	0.755	1	0	1
Circus pygargus	24877885	60.71	35	50000	1	0	1
Cisticola juncidis	163848711	51.15	35	665000	0	0	0
Clamator glandarius	59374967	44.79	35	67500	0	0	0
Clangula hyemalis	49483737	82.22	51.71	720000	1	0	1
Coccothraustes coccothraustes	46328895	62.5	35	3300000	1	0	1
Columba bollii	19145	35	35	6250	0	0	0
Columba junionae	19145	35	35	1750	0	0	0
Columba livia	102111594	70	35	12150000	0	0	0
Columba oenas	31125952	65	35	625000	0	0	0
Columba palumbus	42222969	67.33	35	13000000	0	0	0
Columba trocaz	686	35	35	10550	0	0	0
Coracias garrulus	27947574	60.5	35	81500	0	0	0
Corvus corax	116351764	81	35	710000	0	0	0
Corvus corone	57070552	71.17	35	12000000	0	0	0
Corvus frugilegus	47448563	65.33	35	14000000	0	0	0
Corvus monedula	31652899	66.36	35	10100000	0	0	0
Corvus ruficollis	43735051	35.43	35		0	0	0
Coturnix coturnix	138134721	61.25	35	3750000	1	0	1
Crex crex	24591322	68	40.83	1650000	0	0	0
Cuculus canorus	79987916	70.47	35	6400000	0	0	0
Cuculus saturatus	82337843	50.45	35	375000	0	0	0

Species	Breeding range (km²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
Cursorius cursor	44734680	40	35	0.36	0	0	0
Cyanopica cyanus	1669659	53.91	35	360000	0	0	0
Cygnus columbianus	24434047	72.38	55.45	10000	0	0	0
Cygnus cygnus	32594300	70	45.58	18500	0	0	0
Cygnus olor	30854760	62.41	35.92	103000	0	1	1
Delichon urbica	86520645	70.33	35	16950000	0	0	0
Dendrocopos leucotos	62001980	64.82	35	365000	0	1	1
Dendrocopos major	79065128	68.67	35	15000000	0	1	1
Dendrocopos medius	14754778	58.7	35	225000	0	1	1
Dendrocopos minor	45996198	70.63	35	775000	0	1	1
Dendrocopos syriacus	9427112	51.54	35	815000	0	1	1
Dryocopus martius	54009695	69.33	35	1070000	0	1	1
Egretta alba	256307748	50	35	17500	0	0	0
Egretta garzetta	180897650	49.08	35	81000	0	0	0
Elanus caeruleus	137707888	40.73	35	1405	0	0	0
Emberiza aureola	29976359	68.17	40	60000	1	1	1
Emberiza brunniceps	8171900	49.4	35	0.625	1	0	1
Emberiza buchanani	14835912	51.82	35	13200	1	0	1
Emberiza caesia	1979136	41.04	35	185000	1	0	1
Emberiza cia	21375695	51.82	35	2700000	1	0	1
Emberiza cineracea	470123	39.35	36.74	5200	1	0	1
Emberiza cirlus	10526563	51.73	35	3600000	1	1	1
Emberiza citrinella	26826063	70.44	38.91	24500000	1	1	1
Emberiza hortulana	27681228	67.5	35	10600000	1	0	1
Emberiza leucocephalos	26353704	68.89	35	0.075	1	0	1
Emberiza melanocephala	10976526	47.8	35	6050000	1	1	1
Emberiza pallasi	17872157	71.43	45.22	115000	1	0	1
Emberiza pusilla	11732608	70.29	56.36	6500000	0	0	0
Emberiza rustica	19690540	68.67	50.9	8050000	1	0	1
Emberiza schoeniclus	55690608	71.18	35	6800000	1	0	1
Emberiza striolata	23851423	35.65	35		1	0	1
Eremalauda dunni	14348353	35	35		0	0	0
Eremophila alpestris	59723033	73.83	35	4400000	1	1	1
Eremophila bilopha	10175943	36.14	35		1	1	1
Eremopterix nigriceps	36523947	35	35		1	0	1
Erithacus rubecula	38251134	70	35	63000000	0	0	0
Falco biarmicus	61373886	44.38	35	0.69	1	0	1
Falco cherrug	28545648	59.09	35	0.45	1	0	1
Falco columbarius	60142061	71.09	42		1	0	1
Falco eleonorae	6491767	43.13	35	6050	1	0	1
Falco naumanni	30494411	57.27	35	33500	1	0	1
Falco peregrinus	414461752	75.37	35	18500	1	0	1

Species	Breeding range (km²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
Falco rusticolus	49680402	83.33	51.59	1800	1	0	1
Falco subbuteo	66368745	66.65	35	95500	1	0	1
Falco tinnunculus	202451931	70.63	35	415000	1	0	1
Falco vespertinus	16355333	64.11	42.92	32500	1	0	1
Ficedula albicollis	7661786	58.2	38.91	1900000	1	0	1
Ficedula hypoleuca	31222685	70.67	35	16000000	1	0	1
Ficedula parva	35801053	65	36.84	3900000	0	1	1
Ficedula semitorquata	3083761	45	36	34000	1	0	1
Francolinus francolinus	12586362	41.04	35	12000	1	0	1
Fratercula arctica	29362245	81	42.86	6500000	0	0	0
Fringilla coelebs	43879941	71.25	35	185000000	1	0	1
Fringilla montifringilla	21206352	71.25	50	17500000	1	0	1
Fringilla teydea	27935	35	35	1750	1	0	1
Fulica atra	236002248	66	35	1800000	0	0	0
Fulica cristata	47534848	37.17	35	0.08	0	0	0
Fulmarus glacialis	39811561	81.89	47.8	3600000	0	0	0
Galerida cristata	83319431	57.59	35	5600000	0	0	0
Galerida theklae	25706181	43.33	35	1800000	0	0	0
Gallinago gallinago	361621654	71.25	35	1415000	0	0	0
Gallinago media	12684637	70.63	47.27	116000	0	0	0
Gallinago stenura	13666038	71.43	50.91	1750	0	0	0
Gallinula chloropus	264037374	66		1300000	0	0	0
Garrulus glandarius	70688189	69.83	35	9500000	0	0	0
Gavia arctica	52965781	73.28	41.86	71500	0	0	0
Gavia immer	40351251	77.56	41.82	1500	0	0	0
Gavia stellata	66565237	82.19	44.39	62000	0	0	0
Geronticus eremita	3925676	37.07	35	15000	0	0	0
Glareola normanni	6039961	55.24	41.88	3800	0	0	0
Glareola pratincola	91406600	47.62	35	14000	0	0	0
Glaucidium passerinum	26060857	67.83	41.43	78500	0	0	0
Grus grus	34386572	69.67	36.52	92000	0	0	0
Grus virgo	13648596	52.73	36.36	22500	0	0	0
Gypaetus barbatus	105828315	49.09	35	0.805	0	0	0
Gyps fulvus	32363011	45.58	35	20000	0	0	0
Haematopus ostralegus	46951331	71.25	36.52	375000	0	0	0
Haliaetus albicilla	76333390	70.87	35	5800	0	0	0
Hieraaetus fasciatus	154645128	45	35	1010	0	0	0
Hieraaetus pennatus	32217377	56.2	35	6650	0	0	0
Himantopus himantopus	333140845	53.33	35	50500	0	0	0
Hippolais caligata	24195303	63.57	35	55000	0	0	0
Hippolais icterina	21131336	70	36.84	5300000	0	0	0
Hippolais languida	7199961	44.76	35	25500	0	0	0

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

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

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

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

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

Species	Breeding range (km²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
Sitta tephronota	7093661	42.73	35	61000	0	0	0
Sitta whiteheadi	3650	42.5	41.67	3000	1	0	1
Somateria mollissima	30201352	80.83	42.86	1020000	1	0	1
Somateria spectabilis	16888563	82.22	66.67	41500	1	0	1
Stercorarius longicaudus	39653124	78.89	51.58	45000	0	0	0
Stercorarius parasiticus	46690152	81.75	51.11	90000	0	0	0
Stercorarius pomarinus	17351156	77.03	65.45	35000	0	0	0
Sterna albifrons	206217797	65.94	35	45000	0	0	0
Sterna caspia	242849556	65.94	35	7000	0	0	0
Sterna dougallii	146908338	56.11	35	1850	0	0	0
Sterna hirundo	137032125	71.25	35	420000	0	0	0
Sterna nilotica	82533374	58.83	35	17000	0	0	0
Sterna paradisaea	66381992	81.75	50.59	700000	0	0	0
Sterna sandvichensis	55524756	59.26	39.5	106000	0	0	0
Streptopelia decaocto	84393908	69.67	35	7850000	0	0	0
Streptopelia senegalensis	97574458	45.37	35	135500	0	0	0
Streptopelia turtur	49092131	63.84	35	5350000	0	0	0
Strix aluco	55876079	65	35	740000	0	0	0
Strix nebulosa	41488904	68.83	45.5	4400	0	0	0
Strix uralensis	41750956	68.67	35	96500	0	0	0
Sturnus roseus	11585863	54.55	35.79	134000	1	1	1
Sturnus unicolor	3716312	43.75	35	2600000	1	0	1
Sturnus vulgaris	57229673	71.25	35	39500000	1	1	1
Sula bassana	15246153	70.78	46	305000	0	0	0
Surnia ulula	54632344	70	38.95	23600	0	0	0
Sylvia atricapilla	49004644	70.1	35	37000000	1	0	1
Sylvia borin	24656982	70.31	36.74	24000000	0	0	0
Sylvia cantillans	7240806	46	35	2300000	1	0	1
Sylvia communis	34153491	69.33	35	19500000	1	0	1
Sylvia conspicillata	20177769	46.2	35	310000	1	0	1
Sylvia curruca	44818321	69.67	35	6300000	0	0	0
Sylvia deserticola	1607574	37.61	35		1	0	1
Sylvia hortensis	16088720	47.4	35	325000	1	0	1
Sylvia leucomelaena	5398066	35	35		1	0	1
Sylvia melanocephala	12182597	46	35	5600000	1	0	1
Sylvia melanothorax	24440	35.65	35	105000	1	0	1
Sylvia mystacea	5804712	46.88	35	96500	1	0	1
Sylvia nana	42836194	49.17	35	3000	0	0	0
Sylvia nisoria	17364578	62.5	38.95	730000	1	0	1
Sylvia rueppelli	941133	41.04	35	405000	1	0	1
Sylvia sarda	674571	42.93	36.52	52000	1	0	1
Sylvia undata	4095075	51.35	35	2800000	1	0	1

Species	Breeding range (km²)	N limit	S limit	Population size	Melanin	Carotenoid	Dichrom
Tachybaptus ruficollis	170152125	60.18	35	134500	0	0	0
Tadorna ferruginea	38145652	57.14	35	26000	1	1	1
Tadorna tadorna	38534754	66.17	35	53500	1	1	1
Tarsiger cyaneus	53194293	68	35	15500	1	0	1
Tetrao mlokosiewiczi	517607	45	38.78	84500	1	1	1
Tetrao tetrix	29140443	70	40.93	2850000	1	1	1
Tetrao urogallus	23208757	30.31	41.15	880000	1	1	1
Tetraogallus caspius	1994433	40.83	35	5750	1	0	1
Tetraogallus caucasicus	251888	43.75	40.52	49500	1	0	1
Tichodroma muraria	26203595	49.09	35	69000	1	1	1
Tringa cinereus	21277895	72.73	49	48000	0	0	0
Tringa erythropus	5342798	70.31	63.75	30500	0	0	0
Tringa glareola	22194411	70.78	50	775000	0	0	0
Tringa hypoleucos	56601323	71.25	35	1160000	0	0	0
Tringa nebularia	22863287	70.31	50	117500	0	0	0
Tringa ochropus	31097993	68.83	40	565000	0	0	0
Tringa stagnatilis	13130763	60.91	44.38	22000	0	0	0
Tringa totanus	52792516	71.09	35	445000	0	0	0
Troglodytes troglodytes	85810285	69.33	35	31500000	0	0	0
Turdoides altirostris	225670	35	35		0	0	0
Turdoides squamiceps	5803178	35	35		0	0	0
Turdus iliacus	25824771	71.17	49	18500000	0	0	0
Turdus merula	86850440	71.17	35	61000000	1	1	1
Turdus philomelos	30851069	70.33	36	28000000	0	0	0
Turdus pilaris	24506818	71.17	44.58	19000000	0	0	0
Turdus ruficollis	16765713	66.65	36	12500	1	0	1
Turdus torquatus	17793028	71.17	36.09	490000	1	0	1
Turdus viscivorus	33724781	69	35	5200000	0	0	0
Tyto alba	419862587	57.45	35	165000	0	0	0
Upupa epops	161518909	60	35	1295000	1	0	1
Uria aalge	54241213	78.89	39.35		0	0	0
Uria lomvia	52613330	81	46.83	2200000	0	0	0
Vanellus vanellus	37072931	70.16	35.79	2250000	1	0	1
Zoothera dauma	78736278	60.71	35	62500	0	0	0