Bird Conservation International (1996) 6:201–211

Geographical variation in the abundance of the Corncrake *Crex crex* in Europe in relation to the intensity of agriculture

R. E. GREEN and M. D. RAYMENT

Summary

The Corncrake *Crex crex* is a rail which inhabits tall grass and herbage and migrates between breeding grounds in northern Eurasia and wintering areas in south-east Africa. Corncrake populations are known to have been declining for more than 100 years in some countries and declines have now been reported for almost all of the European part of the species's world range. It appears that mechanized mowing early in the breeding season reduces the production of young to a point below that needed to maintain the population. It might therefore be expected that Corncrakes would be least abundant in countries where the management of agricultural grassland is most mechanized and intensive. To test this hypothesis, an analysis of available statistics for agricultural intensity and Corncrake population density in different European countries was undertaken. Milk yield per dairy cow and measures of the use of fertilizers and tractors were used as indices of the intensity of management of agricultural grassland. Corncrakes were least abundant in European countries with high levels of milk yield, fertilizer and tractor use. Countries with low indices of agricultural intensity and high Corncrake abundance are in eastern Europe where continuing political change makes the future course of agricultural development difficult to foresee. The persistence of the Corncrake in this region depends on the adoption of agricultural policies which do not encourage further intensification of grassland management in those areas which support important populations.

Introduction

The Corncrake *Crex crex* is a summer visitor to northern Eurasia and winters in south-east Africa (Stowe and Becker 1992). The species lives in tall vegetation throughout the year and, in the breeding season, is strongly associated with agricultural grassland managed for the production of hay and silage (Cramp and Simmons 1980). Corncrake numbers and geographical range have been declining since the late nineteenth century and especially since the 1950s (Tucker and Heath 1994). Population declines were first noticed in Britain, Ireland, Fennoscandia, western and central Europe and have now been reported from almost all of the states in the European part of the breeding range. The declines are continuing, though there are still thought to be at least 184,000 breeding adults in Europe (Tucker and Heath 1994). Numbers and population trends in the Asian part of the range in Siberia are unknown. As a result of these long-term and continuing population declines the Corncrake is listed as

https://doi.org/10.1017/S0959270900003105 Published online by Cambridge University Press

being threatened with global extinction (Collar *et al.* 1994; Groombridge 1994) and as a Species of European Conservation Concern (Tucker and Heath 1994).

Norris (1947) pointed out that the declines in Corncrake numbers in different parts of England, Wales, Scotland and Ireland between 1850 and 1940 occurred at different times and, in each region, followed the replacement of manual mowing of hay by mowing with horse-drawn machines. Hay-meadows were, and remain, important habitat for Corncrakes and mortality of adults and chicks and destruction of nests was observed when mechanical mowing replaced manual mowing (Norris 1947). Adult Corncrakes and their chicks, being reluctant to break cover, tended to become trapped in the centre of the field when mowing machines worked from the outside of the field inwards. Norris (1947) also suggested that increased mortality and nest losses might also have been caused by earlier mowing, but changes in the average date of mowing had occurred only in some of the areas in which declines had occurred by 1940. However, in the second half of the twentieth century increased fertilizer application and reseeding with more productive grass varieties has led to an increase in the proportion of grass harvested as silage rather than hay, to earlier mowing dates and to a higher incidence of mowing two or more crops of silage per year. The effect of mowing on Corncrake population trends is likely to be determined both by the speed and method of mowing and the degree of overlap between the mowing season and the birds' breeding season (Green 1995a). The combination of rapid mechanized mowing with an early and short mowing season is expected to produce the most rapid declines. Corncrake populations are expected to persist at high density only where mowing is late or where it has not been mechanized and the method used allows most Corncrakes to escape from the meadow.

The hypothesis that Corncrake population declines have been caused by mechanized and earlier mowing of hay and silage is supported by the coincidence of the declines and mechanization in Britain and Ireland in the nineteenth and early twentieth centuries (Norris 1947; Green 1995a) and also by more recent data. Corncrake population trends in different parts of Britain and Ireland in the period 1988–1991 were correlated with average grass mowing dates. Rapid declines occurred and population densities were lowest where the mean mowing date was before late July (Green and Williams 1994; Green 1996). An association between recent declines in Corncrake populations in France and early mowing has also been reported (Broyer 1994).

It is well known that the abundance of Corncrakes varies considerably within the European part of the breeding range but there has been no previous attempt to relate these differences to agricultural practices. On the basis of the studies of Corncrake ecology and population trends described above it would be expected that Corncrakes should be least abundant in areas where the intensification of management of agricultural grassland and mechanization of mowing had proceeded the furthest. In this paper we take the opportunity provided by the recent publication of Corncrake population estimates for most of the European range (Tucker and Heath 1994) to test this prediction.

https://doi.org/10.1017/S0959270900003105 Published online by Cambridge University Press

Materials and methods

Corncrake population density

Corncrake numbers were taken from the table on page 228 of Tucker and Heath (1994), which gives maximum and minimum numbers of "pairs" for each country. Corncrakes do not form long-term pair bonds (Schäffer and Munch 1993; Tyler and Green 1996), so the estimates actually refer to numbers of singing males. Minor errors in the totals for the United Kingdom and the Republic of Ireland were corrected (see Sheppard and Green 1994; Green 1995b). Further details of the estimates, which vary considerably in quality, are given in Tucker and Heath (1994). The surveys upon which the estimates were based, where dates are given, fall within the period 1981–1993. Where a range of numbers was given, the mean of the lower and upper bounds was taken as the best estimate.

The countries for which population estimates are available vary considerably in size so an average population density of Corncrakes was calculated. Ideally this would have been done by dividing by the area of potentially suitable habitat, since it would be misleading to include in the calculation areas of high mountains, deserts, etc. However, it was difficult both to arrive at a definition of potentially suitable habitat and to obtain estimates of its area for all countries. Therefore we excluded data from countries where Corncrakes have apparently never bred on a large part of the land surface for climatic reasons (see below) and, for the remaining countries, we calculated two measures of the average Corncrake population density: one by dividing Corncrake numbers by the area of agricultural land (taken from FAO (1994)), the other by dividing by the total land area.

Selection of agricultural statistics

All agricultural statistics were taken from FAO (1994) and FAO (1995). These data are the only statistics available for all of the relevant countries, which include the central and eastern European countries and the newly independent states of the former Soviet Union. However, it should be noted that they are drawn from a wide range of sources and are therefore likely to be of variable reliability, particularly in newly independent countries for which data have only recently become available. In addition, the large number of countries included in the analysis restricted the number of variables for which data were available.

Statistics were selected which were both available for most countries in the Corncrake's breeding range in Europe and likely to correlate with aspects of the management of agricultural grasslands which influence Corncrake habitat suitability and breeding success. Statistics are not widely available on the factors expected to affect Corncrakes directly, such as the degree of mechanization of hay and silage mowing and the timing of mowing and number of cuts per season of hay and silage, so the following variables were obtained as surrogates.

Milk production per cow It was considered that countries with the most intensively managed agricultural grassland would also tend to have high yields

https://doi.org/10.1017/S0959270900003105 Published online by Cambridge University Press

of milk per milk-producing cow. The quantity of cow milk (tonnes) per year was divided by the number of milk-producing cattle.

Mechanization of agriculture The prevalence of the use of tractor-powered mowing machinery is expected to influence the rate at which hay and silage can be harvested and hence increase the proportion of the area of hay and silage meadows which is mowed during the Corncrake's breeding season. The proportion of Corncrake chicks able to escape during mowing is also expected to diminish after mechanization (Norris 1947; Green 1995a). An index of the use of tractor-powered machines in agriculture relative to the use of labour-intensive methods was obtained by dividing the number of tractors by the number of economically active persons in agriculture. It was not possible to obtain separate estimates of the numbers of tractors used in livestock farming and tillage.

Fertilizer use An index of fertilizer use was calculated by dividing the total quantity of fertilizer used by the number of economically active persons involved in agriculture. No data on fertilizer were available for Liechtenstein.

Years for which agricultural statistics were used

Annual statistics are available from FAO but we used data for 1992 for most purposes because this was the first year in which separate statistics were available for the newly independent countries which had been part of the USSR and Yugoslavia. However, using data for 1992 had the disadvantage that the data for many eastern European countries were likely to be affected by large changes in the economics of agriculture brought about by political changes in the late 1980s and early 1990s. Numbers of Corncrakes would be expected to be influenced by conditions prevailing over a long period, rather than by two or three years with atypical economic pressures on agriculture. Therefore the statistics for 1992 were compared, where possible, with those for 1987 to assess the magnitude of changes from the situation prevailing before the period of rapid political change.

Countries included in the analysis

Tucker and Heath (1994) give population estimates for 33 political units but the number of units used in the analysis was reduced to 23 by omission and amalgamation of some for the following reasons. The Isle of Man was omitted because FAO do not publish its agricultural statistics separately. The Russian Federation was omitted because much of the Corncrake's range in that country lies in Asia, but the population estimate available refers only to European Russia. Norway, Sweden, Finland, Italy, Spain and Turkey were omitted because the range of the Corncrake has not extended over more than 50% of the land area of these countries in historical times, probably because of restrictions of the range by factors related to climate. This also applies to the Russian Federation. Data for Belgium and Luxembourg and for the Czech Republic and Slovakia were combined because the required agricultural statistics were not all available separately for their components.

https://doi.org/10.1017/S0959270900003105 Published online by Cambridge University Press

Table 1. Pearson correlation coefficients between agricultural statistics for 1992 and the equivalent statistics for 1987 and means and ranges for the ratio of the 1992 to the 1987 value

		Ratio 1992 : 1987		
	Pearson r	Mean	Range	Number of countries
Milk yield	0.985	1.030	0.896–1.130	17
Tractors per farmworker	0.993	1.126	0.949–1.304	16
Fertilizer per farmworker	0.948	0.717	0.133–1.112	16

It was noticed that there was a marked difference in Corncrake abundance and agricultural statistics between countries in central and eastern Europe, which have until recently had planned economies, and those in western Europe with capitalist or mixed economies. For brevity these two groups of countries are referred to as "western" (Austria, Belgium/Luxembourg, Denmark, France, Ireland, Liechtenstein, Netherlands, Switzerland, United Kingdom) and "eastern" (Belarus, Bulgaria, Croatia, Czech Republic and Slovakia, Estonia, Hungary, Latvia, Lithuania, Moldova, Poland, Romania, Slovenia, Ukraine). Results for Germany were considered separately because its two parts had different economic systems until recently.

Latitude and longitude The central point of each country was estimated by eye on a Bonne projection map and its latitude and longitude obtained to the nearest degree.

Results

Comparison of agricultural statistics for 1987 and 1992

This comparison was necessary to ascertain whether recent changes (such as political developments in the eastern European countries) had caused substantial changes in the agricultural statistics which would make the 1992 data atypical. Values for milk yield, tractors per farmworker and total fertilizer use per farmworker were calculated for the 15 countries of those listed in the Appendix for which data were available both for 1987 and 1992 (14 countries in the case of fertilizer because there were no data for Liechtenstein). Data were not available for 1987 for individual republics of the former USSR or former Yugoslavia, so values were used for the whole of the USSR and Yugoslavia for 1987 and for the same areas in 1992 by aggregating data for all the republics of which they were previously comprised.

Pearson correlation coefficients were calculated between the 1992 and 1987 values of each of the agricultural statistics (Table 1). There were very high correlations (r>0.98) for milk yield and tractors per farmworker, but the correlation was lower (r = 0.948) for fertilizer per farmworker. Ratios of 1992 to 1987 values were obtained for each country and each agricultural statistic (Table 1). The mean value of this ratio was significantly (t_{15} = 4.20, P<0.001) greater than 1 (indicating an increase) for tractors per farmworker and significantly (t_{15} = 3.45, P<0.01) less than 1 (indicating a decrease) for fertilizer per farmworker. There was no significant change for milk yield. There was much

https://doi.org/10.1017/S0959270900003105 Published online by Cambridge University Press

Table 2. Kendall rank correlation coefficients between pairs of variables identified by letters *a–g*

	b	*c*	*d*	*e*	*f*	*g*
a Corncrake density (agricultural land)	0.976***	0.058	0.508***	−0.478**	−0.328*	−0.516*
b Corncrake density (all land)		0.050	0.516***	−0.486**	−0.336*	−0.538**
c Latitude			−0.051	0.225	0.258	0.478*
d Longitude				−0.500***	−0.540***	−0.589**
e Milk yield (1992)					0.470**	0.516*
f Tractors per farmworker (1992)						0.516*
g Fertilizer per farmworker (1987)						

Coefficients were calculated for the 23 countries or country groups listed in the Appendix, except for correlations involving variable *g* for which data were available for 14 countries. Asterisks indicate two-tailed statistical significance levels: * = $P<0.05$, ** = $P<0.01$, *** = $P<0.001$.

greater variation among countries in the 1992 : 1987 ratio for fertilizer per farmworker than for the other two agricultural statistics. Inspection of the data revealed that this was because fertilizer per farmworker fell in eastern European countries (mean 1992 : 1987 ratio = 0.384, range 0.133–0.520, $n = 7$), but remained approximately constant in western European countries (mean ratio = 1.011, range 0.949–1.112, $n = 8$). Germany was excluded from this comparison. We concluded from these analyses that the 1992 values of milk yield and tractors per farmworker could be taken as reasonable indices of recent differences in these statistics among countries but that the large changes in fertilizer use per farmworker between 1987 and 1992 made it unsafe to use 1992 data for this variable. Therefore the 1987 data were used. This restricted the sample of countries for which data on fertilizer use was available because the republics of the former USSR and former Yugoslavia could not be included.

Relationship of Corncrake density to agricultural statistics, latitude and longitude

The original data and derived variables are listed for each country in the Appendix. Kendall rank correlation coefficients were calculated for every pairwise combination of variables (Table 2). The two measures of Corncrake population density were highly correlated and therefore the conclusions presented below about their relationships with other variables are similar.

There were significant negative correlations between both measures of Corncrake density and milk yield, tractors per farmworker and fertilizer per farmworker (Table 2, Figure 1). Corncrake density was also significantly correlated with longitude, being greater in the east than the west, but not with latitude (Table 2, Figure 1). Milk yield, tractors per farmworker and fertilizer per farmworker all showed significant negative correlations with longitude.

Figure 1 shows that all of the correlations are largely accounted for by differences between western European and eastern European countries, the western countries having lower densities of Corncrakes (Mann–Whitney U test for both measures of Corncrake density $U_{9,13} = 10$, $P = 0.001$) and higher values of the three agricultural statistics (milk yield, $U_{9,13} = 3$, $P<0.001$, tractors per farmworker, $U_{9,13} = 0$, $P<0.001$, fertilizer per farmworker, $U_{5,8} = 5$, $P = 0.028$). Germany was excluded from these comparisons.

The strong correlation of the agricultural statistics with longitude makes interpretation of the correlations of Corncrake density and agricultural statistics

https://doi.org/10.1017/S0959270900003105 Published online by Cambridge University Press

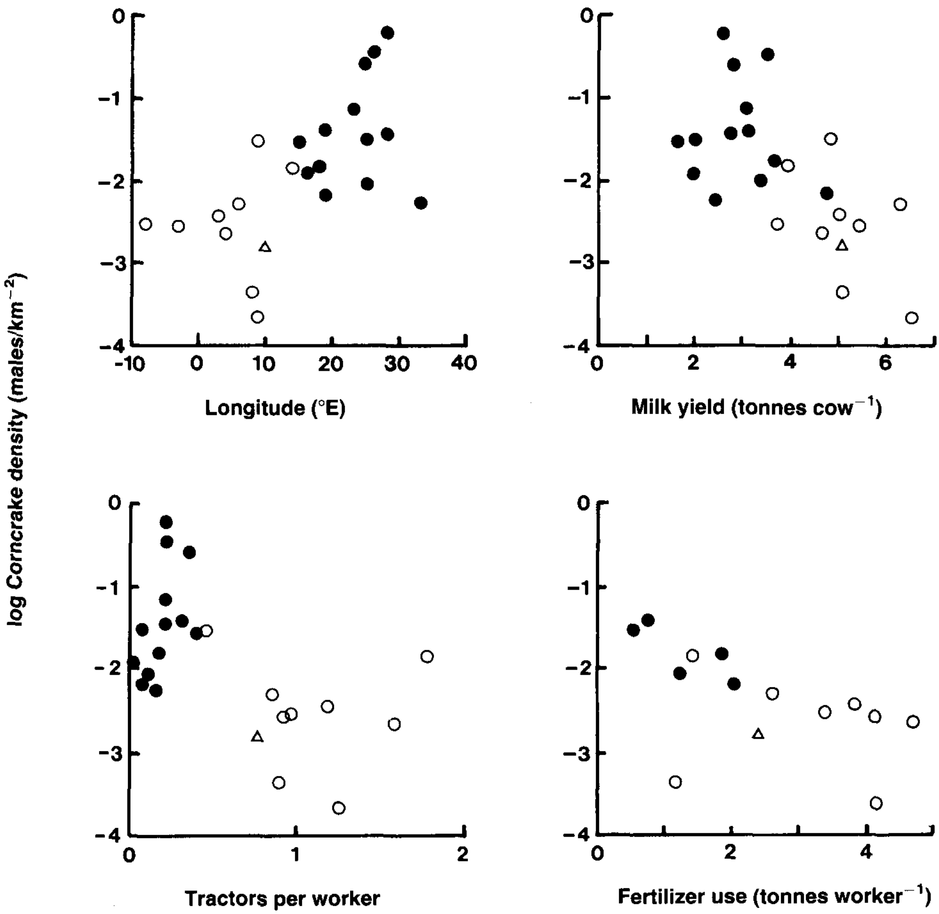

Figure 1. Corncrake density, expressed in males per km^2 of agricultural land and plotted, after $\log_{10}$ transformation, in relation to longitude, milk yield index, tractors per farmworker and fertilizer use per farmworker. Eastern European countries are indicated by filled circles, western European countries by open circles and Germany by an open triangle.

difficult. However, an attempt to isolate the effects of the agricultural statistics from that of longitude by partial rank correlation (Siegel and Castellan 1988) indicated significant correlations of Corncrake density with milk yield and fertilizer use per farmworker even when the effect of longitude was taken into account (Table 3). The partial correlation analysis indicated a weaker effect of tractors per farmworker.

Discussion

Average population densities of Corncrakes varied over three orders of magnitude among countries. This variation may be partially due to the inaccuracy of some population estimates but it is certain from atlas studies of distribution within countries that there is also substantial real variation in Corncrake abundance.

https://doi.org/10.1017/S0959270900003105 Published online by Cambridge University Press

Table 3. Kendall partial rank correlation coefficients between Corncrake density on agricultural land or all land and agricultural statistics, with the effect of longitude partialled out

Independent variable	Correlation coefficient for Corncrake density on Agricultural land	All land
Milk yield (1992)	−0.300*	−0.307*
Tractors per farmworker (1992)	−0.074	−0.079
Fertilizer per farmworker (1987)	−0.463**	−0.415*

Asterisks indicate two-tailed statistical significance levels: * =$P<0.05$, ** = $P<0.01$.

There were significant negative correlations between Corncrake population density and the variables we derived from national agricultural statistics to reflect the intensity and degree of mechanization of agriculture. We consider the most plausible interpretation of these correlations to be that densities of Corncrakes were at one time more similar between countries, that much of the variation now apparent is caused by the greater impact of mowing mechanization on Corncrake breeding success in some countries, and/or the longer period over which mechanization and intensification have been exerting their effects. If this interpretation is correct then Corncrakes should previously have been much more widespread and abundant in countries where their density is now low. Changes in numbers and distribution should be less and more recent in countries where the density is now high. There is clear evidence of large declines in numbers and distribution in several western countries in which densities are now low. These changes are especially well documented in Great Britain, Ireland and France (Norris 1947, Broyer 1985, 1994, Dubois 1989, Sheppard and Green 1994, Green 1995b). There is less information on changes in Corncrake numbers in countries where the density is high at present. Population declines have been reported for most of these countries (Tucker and Heath 1994) but appear to be less rapid or to have been in progress for a shorter time than those in western countries where densities are now very low. Too few good quality data are available on the timing and rate of population declines for whole countries for a formal test of this hypothesis to be feasible.

The countries in which Corncrake population density was high and the measures of agricultural intensification and mechanization were low are in eastern Europe. This positive correlation with longitude suggests some other possible causes of variation among countries in Corncrake population density. Climatic factors which differ from west to east, or which have changed over time at different rates according to longitude, might be implicated. However, patterns of change in Corncrake numbers and distribution within countries are not consistent with a general tendency for Corncrakes to be more abundant in the east or in areas with a more continental climate. For example, both in Britain and Ireland, the opposite tendency for Corncrake populations to have declined less rapidly in the north-west than in the south-east has been evident for more than 100 years (Green 1995a). This pattern is consistent with within-country differences in the rate and timing of changes in agriculture.

Another possible cause of the difference in Corncrake population density between western and eastern Europe is a change in climate or ecological conditions along the migration route or in the wintering grounds, if these

https://doi.org/10.1017/S0959270900003105 Published online by Cambridge University Press

differ for birds from different breeding areas. Differences in climate change among the wintering grounds of different subpopulations of White Stork *Ciconia ciconia* from western-central Europe (west Africa) and eastern Europe (eastern and southern Africa) are believed to have contributed to differences in population trends, although agricultural change on the breeding grounds is also implicated in causing declines (Bairlein 1991). There are not enough ringing recoveries for us to know whether Corncrakes from different breeding areas use different wintering areas. The available data indicate that all Corncrakes winter in the eastern parts of central and southern Africa (Stowe and Becker 1992). However, it seems likely that migration routes will differ for birds from western and eastern Europe, at least in the parts of the route north of the Equator. So far no obvious causes of Corncrake population declines have been identified from the migration route and wintering areas (Stowe and Becker 1992).

We conclude that the prediction derived from earlier studies of Corncrakes – that population densities should be higher in countries with less intensive and less mechanized agriculture – is supported by the available data. As with all studies based on correlation, this finding cannot be regarded as establishing a firm link between agricultural change and Corncrake populations but it provides confirmation of other evidence based on more intensive studies (e.g. Stowe *et al.* 1993, Green and Stowe 1993). If our conclusion is correct the persistence of the world's largest remaining Corncrake populations depends on the ways in which future political and economic change affects agricultural practice in eastern Europe. If mechanization increases and dates of mowing of agricultural grassland become earlier in eastern Europe then the large populations of Corncrakes there may soon disappear. The proposed accession of the central and eastern European countries and newly independent Baltic states to the European Union, and hence the Common Agricultural Policy (CAP), is therefore of considerable concern. The intensification of grassland management in western Europe described in this paper has been stimulated by agricultural policies designed to increase production, such as the CAP, which, by supporting milk and beef prices, has encouraged farmers to strive for higher yields. The future of the Corncrake depends on this process not being mirrored in eastern Europe. It is important therefore that future policy developments take account of the implications for agricultural biodiversity, as well as the budgetary, trade and socio-economic considerations of bringing eastern European countries under the CAP. A prudent conservation strategy therefore requires the use of agri-environment measures and site protection to safeguard or restore Corncrake populations in both eastern and western Europe.

Acknowledgements

We are grateful to Mr Christian A. Chikhani and Mr S. Zarqa of the Statistics Division, Food and Agricultural Organization of the United Nations, Rome, who were most helpful in providing data and responding to statistical enquiries. Mark Avery, Mike Pienkowski and Gwyn Williams made constructive criticisms of a draft.

https://doi.org/10.1017/S0959270900003105 Published online by Cambridge University Press

Appendix. Data and derived variables used in the analyses.

Key: (1) country or group of countries, (2) minimum number of singing male Corncrakes, (3) maximum number of singing male Corncrakes, (4) number of economically active persons in agriculture (thousands), (5) milk production (thousands of tonnes), (6) number of milk-producing cattle (thousands), (7) total fertilizer use (thousands of tonnes), (8) number of tractors, (9) agricultural land (km^2), (10) all land (km^2), (11) latitude (°N), (12) longitude (°E), (13) Corncrakes per km^2 of agricultural land, (14) Corncrakes per km^2 of all land, (15) tractors per farmworker, (16) milk yield (tonnes per cow), (17) tonnes of fertilizer use per economically active person in agriculture in 1987. All agricultural data except (17) refer to 1992.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Austria	400	600	198	3,287	841	267	351,444	34,920	83,856	47	14	0.014	0.006	1.775	3.908	1.421
Belarus	55,000	60,000	603	5,885	2,314	1,395	127,000	93,910	207,600	53	28	0.612	0.277	0.211	2.543	—
Belgium/Lux.	10	55	72	3,775	815	333	113,480	14,690	33,374	51	4	0.002	0.001	1.576	4.632	4.685
Bulgaria	100	1,000	503	1,589	487	287	47,411	61,540	110,994	42	25	0.009	0.005	0.094	3.263	1.209
Croatia	250	300	435	709	369	190	4,263	22,330	56,538	44	16	0.012	0.005	0.010	1.921	—
Czechoslovakia	800	1,300	724	5,185	1,438	351	115,929	67,300	127,900	49	18	0.016	0.008	0.160	3.606	1.831
Denmark	6	6	124	4,605	708	532	155,031	27,560	40,093	57	9	0.000	0.000	1.250	6.504	4.013
Estonia	5,000	5,000	94	900	500	141	21,000	14,590	45,100	58	26	0.343	0.111	0.223	3.462	—
France	1,050	1,150	1,235	25,315	5,059	4,531	1,460,000	303,540	543,965	47	3	0.004	0.002	1.182	5.004	3.818
Germany	260	260	1,729	27,991	5,548	2,843	1,321,900	171,530	357,050	51	10	0.002	0.001	0.765	5.045	2.344
Hungary	300	500	541	2,301	487	145	40,300	61,360	93,030	47	19	0.007	0.004	0.074	4.725	2.013
Rep. Ireland	165	165	174	5,389	1,459	648	167,500	56,130	70,285	53	-8	0.003	0.002	0.963	3.694	3.350
Latvia	3,000	10,000	160	1,479	531	168	56,665	25,300	64,500	57	25	0.257	0.101	0.354	2.785	—
Liechtenstein	2	4	1	13	3	—	450	100	160	47	9	0.030	0.019	0.450	4.815	—
Lithuania	2,000	3,000	226	2,245	738	167	48,000	35,240	65,200	55	23	0.071	0.038	0.212	3.042	—
Moldova	700	1,100	255	1,128	417	135	53,833	25,600	33,700	47	28	0.035	0.027	0.211	2.705	—
Netherlands	50	150	212	10,909	1,739	543	181,750	19,860	41,863	53	6	0.005	0.002	0.857	6.273	2.565
Poland	6,600	7,800	3,806	13,153	4,236	1,193	1,172,140	187,430	312,677	52	19	0.038	0.023	0.308	3.105	0.742
Romania	3,000	6,000	2,145	3,463	1,782	421	146,790	147,900	237,500	46	25	0.030	0.019	0.068	1.943	0.526
Slovenia	200	300	177	352	220	70	70,000	8,640	20,251	46	15	0.029	0.012	0.395	1.600	—
Switzerland	1	13	128	3,873	768	156	114,000	15,810	41,293	47	8	0.000	0.000	0.891	5.043	1.157
Ukraine	2,000	2,500	3,050	18,955	8,223	2,897	439,501	419,290	603,700	49	33	0.005	0.004	0.144	2.305	—
United Kingdom	488	488	537	14,701	2,719	2,114	500,000	177,200	244,110	53	-3	0.003	0.002	0.931	5.407	4.092

https://doi.org/10.1017/S0959270900003105 Published online by Cambridge University Press

References

Bairlein, F. (1991) Population studies of White Storks *Ciconia ciconia* in Europe. Pp. 207–229 in C. M. Perrins, J.-D. Lebreton and G. J. M. Hirons, eds., *Bird population studies: relevance to conservation and management*. Oxford: Oxford University Press.

Broyer, J. (1985) Le râle de genêt *Crex crex* en France. Union Nationale des Associations Ornithologiques. Centre Ornithologique Rhône-Alpes.

Broyer, J. (1994) La régression du râle de genêt *Crex crex* en France et la gestion des milieux prairiaux. *Alauda* 62: 1–7.

Collar, N. J., Crosby, M. J. and Stattersfield, A. J. (1994) *Birds to watch 2: the world list of threatened birds*. Cambridge: BirdLife International. (BirdLife Conservation Series No. 4.)

Cramp, S. and Simmons, K. E. L. (1980) *Handbook of the birds of Europe, the Middle East and North Africa*, vol. II. Oxford: Oxford University Press.

Dubois, P. J. (1989) Analyse de l'expansion et de la régression de quelques espèces en France. *Aves* 26: 57–68.

FAO (1994) *The state of food and agriculture, 1994*. Rome: Food and Agriculture Organization of the United Nations.

FAO (1995) *Agrostat database*. Rome: Food and Agriculture Organization of the United Nations.

Green, R. E. (1995a). Diagnosing causes of bird population declines. *Ibis* (Suppl.) 137: S47–S55.

Green, R. E. (1995b) The decline of the Corncrake *Crex crex* in Britain continues. *Bird Study* 42: 66–75.

Green, R. E. (1996) Factors affecting the population density of the Corncrake *Crex crex* in Britain and Ireland. *J. App. Ecol.* 33: 237–248.

Green, R. E. and Stowe, T. J. (1993) The decline of the Corncrake in Britain and Ireland in relation to habitat change. *J. App. Ecol.* 30: 689–695.

Green, R. E. and Williams, G. (1994) The ecology of the Corncrake *Crex crex* and action for its conservation in Britain and Ireland. Pp. 67–74 in E. Bignal, D. I. McCracken and D. J. Curtis, (eds.) *Nature conservation and pastoralism in Europe*. Peterborough: Joint Nature Conservation Committee.

Groombridge, B. (1994) ed. *1994 IUCN red list of threatened animals*. Cambridge: World Conservation Monitoring Centre.

Norris, C. A. (1947) Report on the distribution and status of the Corncrake. *Brit. Birds* 40: 226–244.

Schäffer N. and Munch S. (1993) Untersuchungen zur Habitatwahl und Brutbiologie des Wachtelkönigs *Crex crex* im Murnauer Moos/Oberbayern. *Vogelwelt* 114: 55–72.

Sheppard, R. and Green, R. E. (1994) Status of the Corncrake in Ireland in 1993. *Irish Birds* 5: 125–138.

Siegel, S. and Castellan, N. J. (1988) *Nonparametric statistics for the behavioral sciences*. New York: McGraw-Hill.

Stowe, T. J. and Becker, D. (1992) Status and conservation of the Corncrake *Crex crex* outside the breeding grounds. *Tauraco* 2: 1–23.

Stowe, T. J., Newton, A. V., Green, R. E. and Mayes, E. (1993) The decline of the Corncrake in Britain and Ireland in relation to habitat. *J. Appl. Ecol.* 30: 53–62.

Tucker, G. and Heath, M. F. (1994) *Birds in Europe: their conservation status*. Cambridge: BirdLife International (BirdLife Conservation Series No. 3).

Tyler, G. A. and Green, R. E. (1996) The incidence of nocturnal song by male Corncrakes *Crex crex* is reduced during pairing. *Bird Study* 43 (in press).

R. E. GREEN
M. D. RAYMENT
Royal Society for the Protection of Birds, 17 Regent Terrace, Edinburgh EH7 5BN, U.K.

https://doi.org/10.1017/S0959270900003105 Published online by Cambridge University Press