Wintering ducks in the Czech Republic: changes in their population trends and distribution

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Abstract

The Czech Republic, as an inland Central European country, is not part of the core wintering area for most duck species in the Western Palearctic. Nevertheless, inter-seasonal changes in numbers and distribution of particular species are recorded, which may reflect climatic fluctuation. Waterbird counts were carried out annually at 48–639 wetland sites in the Czech Republic in 1966–2008, as part of the International Waterbird Census (hereafter IWC). These data were used to assess long-term trends in the number of duck wintering in the Czech Republic for the 15 most abundant species. Increasing trends were found for six species: Wigeon *Anas penelope*, Mallard *Anas platyrhynchos*, Pochard *Aythya ferina*, Tufted Duck *Aythya fuligula*, Smew *Mergus albellus* and Goosander *Mergus merganser*. Teal *Anas crecca* was the only species found to be declining. Those with stable trends were: Pintail *Anas acuta*, Scaup *Aythya marila*, Velvet Scooter *Melanitta fusca* and Goldeneye *Bucephala clangula*. No (uncertain) trend was found in least abundant Gadwall *Anas strepera*, Shoveler *Anas clypeata*, Red-crested Pochard *Netta rufina* and Ferruginous Duck *Aythya nyroca*. Wintering distribution (measured as the ratio of the number of sites occupied by a given species to the total number of sites investigated) increased in six species (Wigeon, Gadwall, Mallard, Red-crested Pochard, Tufted Duck and Goosander) and decreased in two species (Teal and Ferruginous Duck). No significant changes in distribution were found for the seven remaining species. Changes in numbers correlated with changes in distribution in each species. Annual variation in the numbers and distribution of ducks wintering in the Czech Republic were more strongly associated with long-term trends in numbers than with annual variation in climate conditions. Nevertheless, the numbers of wintering birds recorded on standing waters were positively correlated with climatic variables in 10 duck species.

Key words: changes in distribution, climatic changes, Czech Republic, International Waterbird Census, trends in numbers.

The Czech Republic, as an inland Central European country, is not a core wintering area for most waterbird species, because most of its wetlands usually freeze at some time during the winter (Hudec 1994; Delany *et al.* 1999; Musil *et al.* 2001; Gillisen *et al.* 2002). Nevertheless, year-to-year changes in wintering numbers and distribution of particular waterbird species still occur, which may reflect climatic fluctuations (*e.g.* Fiala 1980). The relatively mild climate and high diversity of smaller wetland habitats in the country may provide some feeding opportunities throughout the winter period for birds which breed in northern Europe, particularly when freezing conditions in the Baltic region may limit the birds' access to feeding areas. Moreover, species with a more southerly distribution, which usually leave central Europe to winter in Mediterranean areas (Musil *et al.* 2001; Cepák *et al.* 2008), may delay southbound movement in milder winters. The Czech Republic therefore provides attractive wintering areas for various duck species (Hudec 1994; Hudec *et al.* 1995).

This study provides a recent (2004–2008) estimate of numbers for the different duck species wintering in the Czech Republic. Moreover, it considers whether there have been any long-term (1966–2008) trends in their numbers and mid-winter distribution. The trends in numbers recorded for each species were investigated in relation to annual variation in weather at both the local and European level, with the former considered likely to influence local distribution and the latter the number of birds occurring in the Czech Republic. A comparative analysis of trends on sites with running and with standing water was undertaken to identify areas likely to attract birds under differing conditions.

Methods

Duck censuses

Long-term trends in the numbers and distribution of duck species were analysed using count data recorded in the Czech Republic for the International Waterbird Census (IWC), in mid-January each winter from 1966–2008 inclusive. The IWC counts were carried out at 48–200 wetlands sites in January 1966–2003 (Fiala 1980; Musil *et al.* 2001). The coverage of sites in the Czech Republic has been more extensive since January 2004. In total, 479–639 sites were counted annually in January 2004–2008 (Musilová & Musil 2006; Musilová *et al.* 2008). Altogether, 2,275,477 birds of 25 duck species were recorded at 1,078 wetlands in the Czech Republic over the years 1966–2008.

Total numbers and trends

Trends in numbers for the 15 most abundant duck species were analysed using IWC data from 847 of the 1,078 sites. Only those sites which had been counted in at least two winters over the 1966–2008 period were included. Log-linear Poisson regression analysis was used to estimate missing data using TRIM software (Statistic Netherlands version 3.52, see http://www.cbs.nl/en-GB/menu/themas/natuur-milieu/methoden/trim/default.htm) (Pannekoek & Van Strien 2001). Serial correlation between annual numbers and overdispersion in the data were taken into account on developing the models used to calculate trends of wintering population of investigated species. The models included changepoints to allow for changes in the slope parameters at some time points in the time series (Pannekoek & Van Strien 2001; Fougue *et al.* 2007).

The multiplicative slope (*i.e.* the change in indices from one year to the next) was the value used to express population trends over the study period. "Time total" values (*i.e.* the sum of actual count values plus the numbers of birds estimated by TRIM for all 847 sites included in the analysis) were used for further analysis of the effects of climatic variables and for estimating numbers of particular duck species wintering in the Czech Republic. Rounded time total values were used to estimate the total numbers of birds present in 2004–2008. Additionally, two separate analyses were carried out of trends in numbers of birds occurring on two main wetland habitat types, *i.e.* running water (444 sites) and standing water (403 sites). For running waters, sites were defined as river sections with known boundaries, such as dams, weirs and bridges; standing water sites included ponds, reservoirs, gravel and sand pit lakes, and industrial settling ponds (Chytil *et al.* 1999).

Distribution of species

The distribution of each species was described as the ratio (arcsin transformed) of the number of sites occupied by that species to the total number of sites investigated. Linear regression analysis was then used to identify potentially significant long-term changes in species distribution. Correlation coefficients derived from the linear regression analyses were used to describe the change in species distribution over the study period for each species (Table 1).

Climate data

Climate data were considered at both the local (Czech Republic) and the European levels. Local climatic conditions were expressed as the monthly mean temperature measured at seven meteorological stations in the Czech Republic. North Atlantic Oscillation (NAO) indices (www.cru.uea.ac.uk; Hurrell 1995) were used as a broader estimate of climatic conditions across Europe. Temperature and NAO for both December and January were included as covariates in the analyses to determine potential effect not only of current weather conditions but also weather in the month prior to the January counts.

There was a significant linear correlation between the monthly mean temperature recorded in the Czech Republic and the NAO index both in December ($F_{1,41}$ = 18.71, r = 0.56, P < 0.01) and in January ($F_{1,41}$ = 49.09, r = 0.74, P < 0.001). Significant correlations were also found between December and January values both for temperature in the Czech Republic ($F_{1,41}$ = 4.848, r = 0.33, P < 0.05) and for the NAO indices ($F_{1,41}$ = 5.343, r = 0.340, P < 0.05). Surprisingly, there were no significant long-term changes in monthly mean temperature (December: $F_{1,41}$ = 0.045, r = 0.03, n.s., January: $F_{1,41}$ = 2.73, r = 0.25, n.s.) or NAO index values (December: $F_{1,41}$ = 0.03, r = 0.03, n.s, January: $F_{1,41}$ = 1.14, r = 0.17, n.s.). This allowed the analysis of the effect of annual climatic variables on the numbers and distribution of particular species to be done whilst distinguishing this effect from that of long-term trends in numbers.

Redundance analyses (RDA) of the effects of long-term changes and climatic fluctuation on numbers and distribution of the different duck species were performed with CANOCO version 4.5 software (ter Braak a Šmilauer 1998). Time totals and the arcsin-transformed ratios of occupied sites for each species were included as

Table 1. Wintering duck numbers in the Czech Republic: wintering numbers estimate (range for 2004–2008), changes in distribution in 1966–2008 (correlation coefficient (*r*) and significance: * $P < 0.05$, ** $P < 0.01$, n.s. = not significant; $n = 43$) and changes in numbers in 1966–2008 (multiplicative rate of change) on all wetlands (total), rivers and standing waters. The trend categories provided by TRIM software are: SI = strong increase, MI = moderate increase, U = uncertain, MD = moderate decline, S = stable.

Species	Population size (individuals) in 2004–2008	Changes in distribution (1966–2008)	Changes in numbers		
			Total	Running waters	Standing waters
Wigeon	70–170	0.726 **	1.061 MI	1.062 MI	1.047 MI
Gadwall	50–300	0.619 **	1.163 U	1.052 MI	1.321 U
Teal	450–1200	–0.319 *	0.974 MD	0.957 MD	1.005 S
Mallard	140,000–180,000	0.576 **	1.008 MI	1.004 MI	1.014 MI
Pintail	15–25	0.122 n.s.	1.016 S	0.998 S	1.055 MI
Shoveler	3–25	0.216 n.s.	1.018 U	0.973 U	1.040 U
Red-crested Pochard	1–3	0.392 *	1.051 U	1.071 U	0.994 U
Pochard	800–1,400	0.276 n.s.	1.031 MI	1.045 MI	0.965 MD
Ferruginous Duck	0–5	–0.317 *	0.942 U	0.943 U	0.993 U
Tufted Duck	3,600–5,100	0.685 **	1.092 SI	1.100 SI	1.011 S
Scaup	8–40	0.114 n.s.	1.201 S	1.024 U	1.015 U
Velvet Scooter	4–25	–0.206 n.s.	1.016 S	0.977 U	1.084 U
Goldeneye	500–1,200	0.181 n.s.	1.004 S	1.005 S	0.995 S
Smew	40–110	0.236 n.s.	1.057 MI	1.056 MI	1.053 U
Goosander	1,500–3,300	0.672 *	1.021 MI	1.019 MI	1.030 MI

dependent variables; year and climatic variables as explanatory ones. Monte Carlo permutations tests (< 500 permutations), used as a randomisation test, were used to test the significance of the model.

Results

Wintering numbers estimate

Wintering numbers estimates are based on counts made for the International Waterbird Census, which has covered 479–639 wetland sites in the Czech Republic each year in recent years (2004–2008). Mallard *Anas platyrhynchos* was recorded as the most abundant wintering duck species in the Czech Republic (140,000–180,000 individuals) in 2004–2008. Furthermore, Teal *Anas crecca*, Common Pochard *Aythya ferina*, Tufted Duck *Aythya fuligula*, Goldeneye *Bucephala clangula* and Goosander *Mergus merganser* exceeded 1,000 individuals in several winter seasons. More than 100 wintering birds were recorded for Wigeon *Anas penelope*, Gadwall *Anas strepera* and Smew *Mergus merganser*. Other duck species reached only low wintering numbers in the Czech Republic during the period (Table 1).

Changes in numbers

Among the 15 investigated species, six species were found to increase and only one to decrease over the period 1966–2008. Trends of four species were found to be stable and trends for the last four species were classed as "uncertain" (see Table 1). A strong increase was apparent for Tufted Duck and a moderate increase was recorded for Wigeon, Mallard, Pochard, Smew and Goosander. Conversely, a moderate decrease was recorded for Teal. Stable species included: Pintail *Anas acuta*, Scaup *Aythya marila*, Velvet Scooter *Melanitta fusca* and Goldeneye. No (uncertain) trend in numbers was found for the less abundant Gadwall, Shoveler *Anas clypeata*, Red-crested Pochard *Netta rufina* and Ferruginous Duck *Aythya nyroca*.

Changes in the number of waterbirds on standing and running waters

Trends in duck numbers on standing waters were found to be increasing for four species, decreasing for one species and to be stable for three species. On running waters, seven species were increasing, one was decreasing and two were stable (Table 1). The number of duck species with an uncertain trend was higher on standing waters (seven species) than on running waters (five species). Three species (Wigeon, Mallard and Goosander) increased in both habitats. Moreover, Pintail increased on standing waters, whereas a further four species (Gadwall, Pochard, Tufted Duck and Smew) increased on running waters. Of all the species considered, only the Pochard increased in numbers on rivers and conversely decreased on standing waters. Numbers of Teal decreased on running waters but were stable on standing waters. The numbers of Goldeneye were stable in both types of wetland habitats. Stable wintering numbers were also found for Teal (see above) and Tufted Duck on standing waters and for Pintail only in running waters.

Changes in distribution

No significant changes in distribution were found in seven species during the study period (Pintail, Shoveler, Pochard, Scaup, Velvet Scoter, Goldeneye and Smew). Distribution (*i.e.* the ratio of occupied sites to the total number of sites counted) increased in six species (Wigeon, Gadwall, Mallard, Red-crested Pochard, Tufted Duck and Goosander) and decreased in only two species (Teal and Ferruginous Duck) during the study period (Table 1).

Changes in numbers (indicated by the multiplicative rate of change values) generally correlated with changes in distribution (correlation coefficient) in each duck species ($y = -4.713 + 4.825\times$; $r = 0.696$, $n = 15$, $P < 0.01$; Fig. 1). Nevertheless, the increase in distribution (number of occupied sites) was more marked than the increase in numbers in Goosander, Mallard and Wigeon, whereas the increase in numbers was more marked than the increase in distribution in Gadwall.

Annual variation in numbers and effect of climatic variables

The analysis of relationships between the number of each species in the Czech Republic (*i.e.* time totals from TRIM) and independent variables (*i.e.* year and climate variables) is plotted in Fig. 2. All ordination axes were statistically significant (Monte-

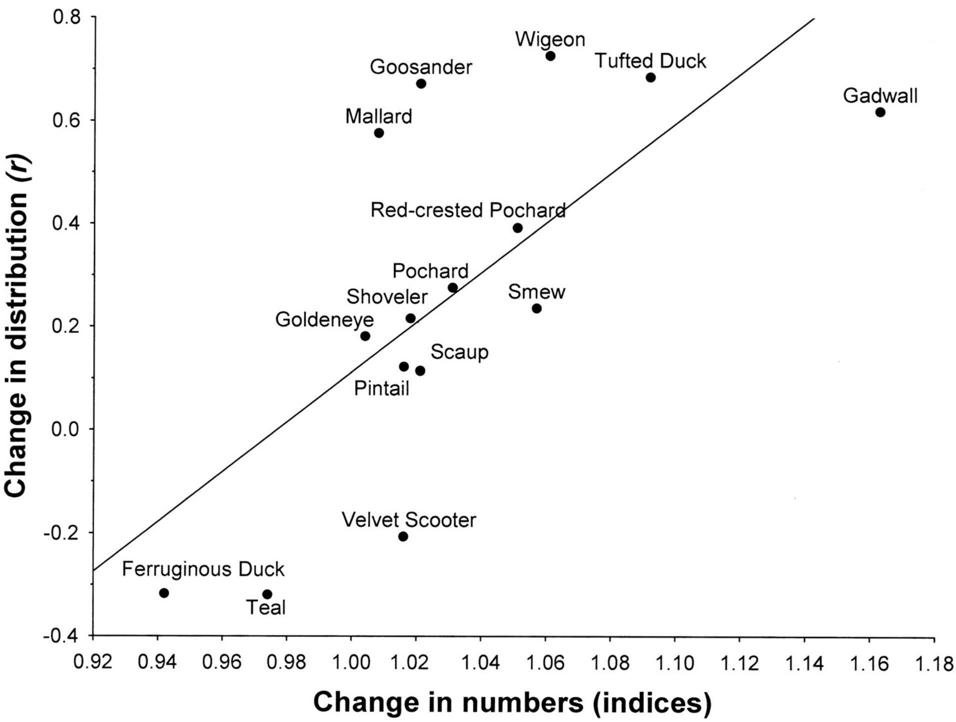

Figure 1. Relationship between changes in distribution (correlation coefficient describing trend in the ratio of the number of sites occupied to sites counted) and changes in numbers (multiplicative rate of change) for each species over the study period.

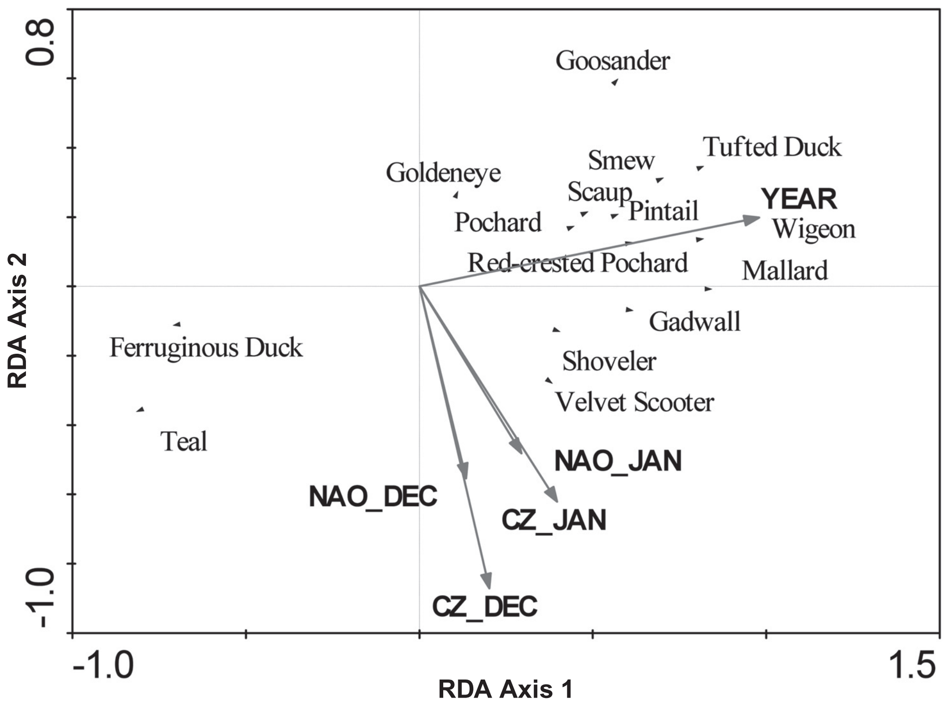

Figure 2. Relationships between the number of each duck species in the Czech Republic (*i.e.* time totals from TRIM) and independent variables (year and climatic variables) determined by redundance analyses. YEAR = winter season (*e.g.* January 1966 = 1966); CZ_DEC = mean December temperature in the Czech Republic (°C); CZ_JAN = mean January temperature in the Czech Republic (°C); NAO_DEC and NAO_JAN = December and January values, respectively, of the North Atlantic Oscillation Index.

Carlo permutation test, F = 18.19, P = 0.002). The 1st and the 2nd RDA axes explained 71.0% of the variation in the species data. The first axis corresponded to population trends in numbers. The second axis corresponded to the species' response to climatic fluctuations, where positive relationships (especially in relation to January weather variables) could be shown for Gadwall, Shoveler and Velvet Scooter and negative relationship for northern species (Goosander, Smew, Goldeneye and Tufted Duck).

The analysis of relationships between numbers (time totals from TRIM) recorded on standing waters and the same independent variables (year and climate variables) were carried out. The 1st and the 2nd RDA axes explained 77.9% of variation in the occurrence of the species on standing waters. All ordination axes were statistically significant (Monte-Carlo permutation test, F = 26.12, P = 0.002). The population trend was positively correlated with both ordination axes. A positive response to climatic variation seemed to be correlated with the 1st ordination axis. In milder winters, increases in numbers were recorded for 10 of the 15 study species on standing water in the Czech Republic (Fig. 3).

Finally, the relationships between the ratio of occupied sites and independent variables (year and climatic variables) were analysed (Fig. 4). The first and the second RDA axes explained 50.7% of variation of the species data. All ordination axes were statistically significant (Monte-Carlo permutation test, $F = 8.315$, $P = 0.002$). The first axis correlated with the trend in distribution. The second axis correlated

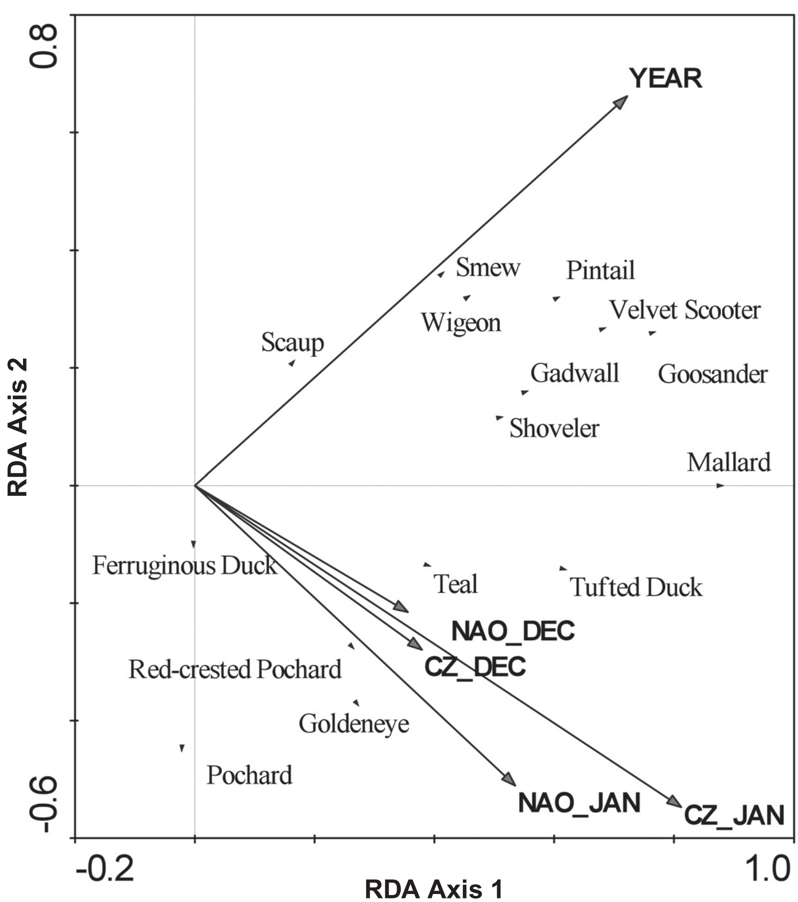

Figure 3. Relationships between the number of each species in the Czech Republic (*i.e.* time totals from TRIM) recorded on standing waters and independent variables (year and climate variables) determined by redundance analyses. YEAR = winter season; CZ_DEC = mean December temperature in the Czech Republic (°C); CZ_JAN = mean January temperature in the Czech Republic (°C); NAO_DEC and NAO_JAN = December and January values, respectively, of the North Atlantic Oscillation Index.

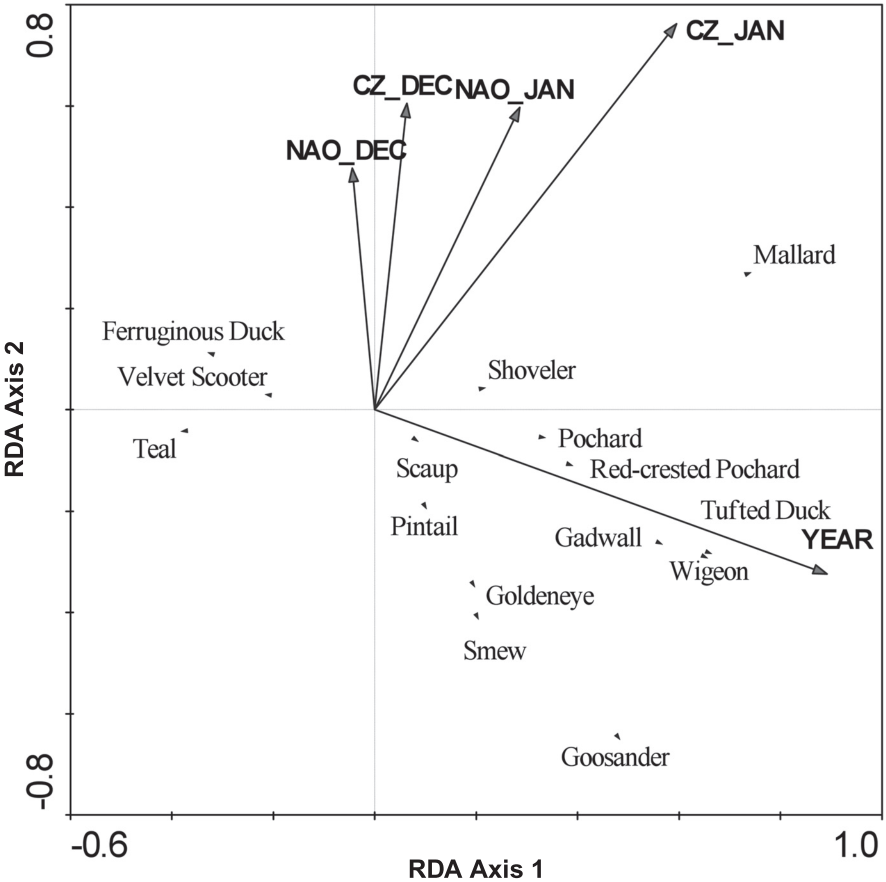

Figure 4. Relationships between the distribution of each species in the Czech Republic (*i.e.* ratio of occupied sites to total sites counted) and independent variables (year and climate variables) determined by redundance analyses. YEAR = winter season; CZ_DEC = mean December temperature in the Czech Republic (°C); CZ_JAN – mean January temperature in the Czech Republic (°C); NAO_DEC and NAO_JAN = December and January values, respectively, of the North Atlantic Oscillation Index.

with species response to climatic fluctuations, and a positive relationship (*i.e.* distribution increased in mild winters) could be shown in Mallard and a negative one (increase in distribution in severe winters) for northern-breeding species that migrate south to the Czech Republic (Goosander, Smew and Goldeneye).

Discussion

Wintering numbers in the Czech Republic are worth considering for duck and other waterbirds. Although only Mallard exceed 100,000 individuals, a total of 15 regularly wintering duck species were recorded in 1966–2008. In contrast to previously published estimates (Hudec 1994; Hudec *et al*. 1995; Musil *et al*. 2001), wintering numbers increased for Wigeon, Gadwall, Pintail, Shoveler, Scaup, Smew and Goosander. Conversely, wintering numbers of Teal decreased; its population changes are thought to be related to the long-term loss and degradation of original wetland habitats in central Europe (Hudec 1994; Chytil *et al*. 1999; Musil *et al*. 2001). The long-term changes in numbers (both increasing and decreasing) corresponded with a change in distribution for all species included in this study (Fig. 1).

Several studies suggest a decrease in wintering numbers of various water and wetland bird species in Western Europe (Wahl & Sudfeldt 2005; Crowe *et al*. 2008; MacLean *et al*. 2008), while on the contrary, wintering population of duck species in central and eastern Europe are mostly increasing (Keller 2006; Darolová *at al*. 2007). Nevertheless, the most recent and broader estimates (*e.g*. Wetlands International 2006) suggest that most populations are increasing in western Europe. Ridgill & Fox (1990) confirmed that there is a shift of ducks and coot to wintering sites in southern and southwest Europe in cold winters, but the present results show that species-specific numbers of ducks in the Czech Republic seem to be more affected by general long-term population trends in the Western Palearctic (Delany *et al*. 1999; Gilissen *et al*. 2002; Birdlife International 2004; Wetlands International 2006), than by seasonal variation in climate conditions.

Surprisingly, no significant long-term (1966–2008) changes in the monthly mean temperature for the Czech Republic and NAO indices (December and January) for Europe were recorded. Nevertheless, given the association between mid-winter climate and numbers recorded on standing waters for several duck species in this study, an increase in the numbers of wintering ducks on standing water in mild winters seems a likely response to global climate change. We therefore expect an increase in the importance of non-freezing standing waters in coming years in accordance with the global climate change forecasts which predict milder winters across Europe, including in the Czech Republic (*e.g*. Huntley *et al*. 2007; IPCC 2007).

Acknowledgements

We are very grateful to all volunteers involved in waterbird counts and also to the census co-ordinators of the International Waterbird Census (IWC) in the Czech Republic. IWC in the Czech Republic was organised in cooperation with Czech Society for Ornithology. The study was supported by the Ministry of Environment of the Czech Republic, Project VaV MŽP R SP/2d3/109/07 entitled *"The long-term changes in numbers and distribution of waterbirds in the Czech Republic in relation to climatic and environmental changes"*. We are also grateful to Matthieu Guillemain, Eileen Rees and an anonymous referee for useful comments which improved our manuscript.

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