Number of waterfowl wintering in Moscow (1985-2004): dependence on climate conditions

Ksenya V. Avilova

Over nineteen years (1985-2004), wintering waterfowl were censused at all Moscow water bodies during the day in the middle of January, thanks to the participation of volunteers under the leadership of the Russian Bird Conservation Union (RBCU). The number of species gradually increased in the study period ($r=0.86$; $p<0.01$; $n=20$). Trends for the four main wintering species (Mallard *Anas platyrhynchos*, Common Teal *Anas crecca*, Common Goldeneye *Bucephala clangula* and Tufted Duck *Aythya fuligula*) are shown. Numbers of Common Teal, Common Goldeneye and Tufted Duck were not dependent on urban weather conditions. The size of the Mallard population was varied with air temperature depending on the particular period and area. The number of Mallard wintering on the Moscow River near the suburbs of the city depended on weather conditions during the initial period of increase in 1985-1992 ($r=0.74$; $p=0.05$; $n=8$) and during the later period of decline in 1993-1998 ($r=0.88$; $p=0.01$; $n=7$). Birds wintering on small rivers and ponds of the inner city depended on weather only in the period of population decline in 1991-1998 ($r=0.83$; $p=0.01$; $n=9$). Dependence on weather conditions, i.e. on air temperature, can be used as measure of the degree of urbanisation of numerous waterfowl species.

Key words: wintering waterfowl, *Anas platyrhynchos*, population dynamics, air temperatures, urbanisation, Moscow, Russia

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Important changes in the wintering populations of waterfowl species were recorded in Eastern and Central Europe over recent decades. They were primarily caused by the general impact of global climate change on wildlife, especially by warmer winters, and also by new man-made ice-free habitats, such as fresh-water reservoirs used for power production, stretches of rivers with the influx of warm urban water, harbours, etc. (Burton 1995, Khrabryi 2002, Randler 2002, Svazas *et al.* 2003). However, some of the local patterns and processes of birds' synurbisation (the adaptation of animal wildlife to urban development; Luniak *et al.* 2004), especially in continental areas with a harsh climate, remain poorly understood.

The phenomenon of urbanisation is vividly pronounced in Central Russia. The human population density in the Moscow Region is 40 times higher than across Russia as a whole (Akimova *et al.* 1994). The impact of Moscow, administrative and territorial centre of the region, is constantly increasing due to expansion of the city, which greatly affects surface water bodies and waterways. This process was associated with intensive social and economic development of the urban agglomeration in the 1970s and 1980s. Construction of high buildings was accompanied by the installation of heating and the consequent development of a network of large power stations to provide heating, for which urban rivers and ponds were used as coolers.

One of the characteristic traits of urbanisation is the alteration of climatic and environmental factors. Nowadays, the frostless period in Moscow city lasts for 25 to 34 days more than that in Moscow Region. The mean yearly ground air temperature in Moscow has increased by

0.6ºC during the two last decades. The functioning of large industrial and municipal structures has also caused an increase in anthropogenic broad-scale eutrophication of rivers and ponds.

The programme of wintering waterfowl counts in Moscow was started in 1985 (Avilova 1993, Avilova *et al.* 2003 a,b). This paper presents the results of 20 years of censusing wintering wildfowl and their relationships with weather conditions in different winters. The aims are: 1) to examine the changes in species richness of wintering waterfowl; 2) to analyze population dynamics in the most numerous species; 3) to assess the extent to which variations in weather explain the observed trends.

Materials and Methods

Thirty-three permanent routes were established along the banks of all non-freezing rivers and ponds inside the Moscow Ring Road. Each year, all census work was done in one day by 25 to 30 teams and single observers. The census date varied from 13 to 25 January in different years. Censuses were never postponed due to bad weather.

Both volunteers (mostly the young members of biology clubs) and professional ornithologists took part in the fieldwork. Each team consisted of 1 to 6 persons and was led by at least one competent observer. Binoculars and sometimes telescopes were used to locate birds and to identify them. During the census, any information coming from volunteers was checked carefully. The identification of the species and the estimation of bird numbers were conducted by competent persons only. Over the last decade, birds were censused under the leadership of the Russian Bird Conservation Union (Russian Partner Designate of BirdLife International).

As a rule, censuses started at c. 10 a.m. local time. Weather conditions, approximate proportions of non-freezing water bodies of rivers and ponds, species of birds, numbers of individuals, their sex and behaviour were recorded. Sites with large concentrations of waterfowl were recorded on a map of the city. As soon as possible after the census, the primary data from different teams were collated, discussed jointly and combined accordingly.

Wintering groups of ducks usually begin to form in November, when most of the water bodies start to become covered with ice, and by mid-

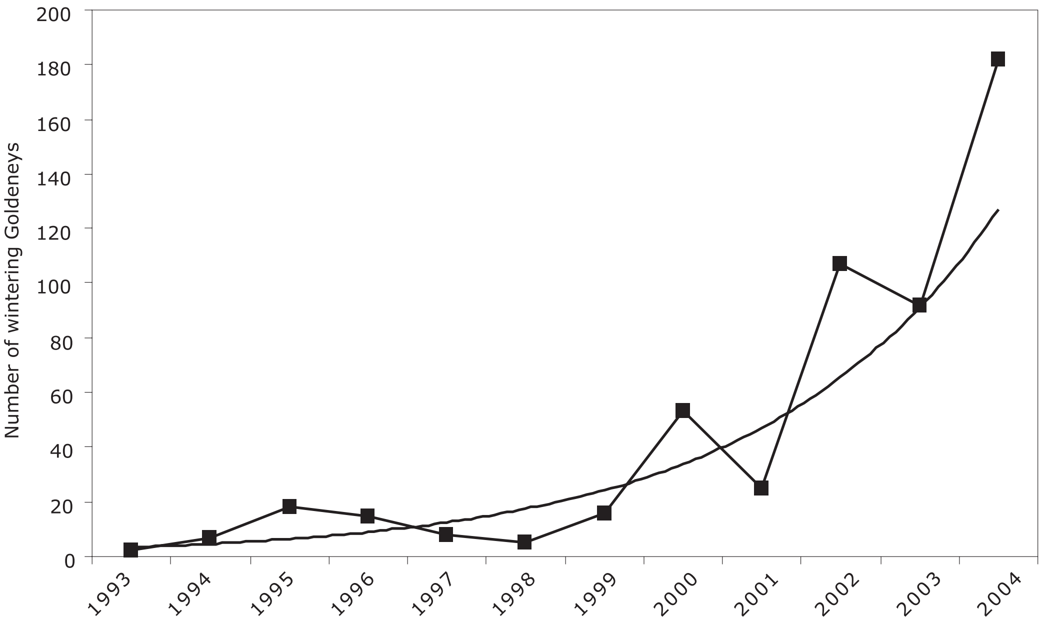

Figure 1. Numbers of wintering Common Goldeneye in 1993-2004.
Nombre de morells d'ulls grocs hivernants al període 1993-2004.

January their numbers tend to become stable. Therefore, we analysed the mean air temperatures of three different parts of the wintering period: November, January, and the overall mean daily air temperature from 1 November to 15 January over each winter (denoted below as MTEW). The latter was used as a measure of weather harshness in late autumn and early winter. The data came from the Meteorological Station of Moscow State University, located in the south-west part of the city.

Results

Twenty-four species of waterfowl were observed between the winters of 1984/1985 and 2003/2004. The number of species recorded varied from 3 to 17 in different years, and increased significantly during the study period (Spearman's rank correlation r_s=0.89; p=0.001; n=20). Wintering waterfowl were unevenly distributed across non-freezing water bodies. Major concentrations were found at the Moscow River, and at large ponds located in extensive parks, as well as at some sections of small rivers surrounded by multi-storey blocks of flats.

Common Goldeneye *Bucephala clangula* were observed mostly at the Moscow River. They were found in low (but, since 1993, rapidly increasing) numbers (r_s=86; p<0.001; n=12, Figure 1). Tufted Duck *Aythya fuligula* was also observed at the Moscow River, and showed an increase in numbers till 1998 (r_s=0.95; p<0.001; n=14), but decreased from 1999 onwards (Figure 2). Common Teal *Anas crecca*, a species common in the Moscow Region, showed a non-significant negative trend during the study period (r_s=-0.13; n.s.; n=20, Figure 3).

Mallard *Anas platyrhynchos* was the most numerous species in winter. The increase in the number of wintering Mallards in the mid-1980s was accompanied by their dispersal through the ice-free parts of the Moscow River and along the main tributaries. Year-to-year changes in Mallard numbers were analysed separately for two major types of non-freezing water body (Figure 4): 1) the non-freezing "lower" segment of the Moscow River, in the central and south-eastern parts of the city, which is typically 35-40 km long and is heavily influenced by water-cleaning stations, and the influx of organic matter and inorganic chemicals from city small riv-

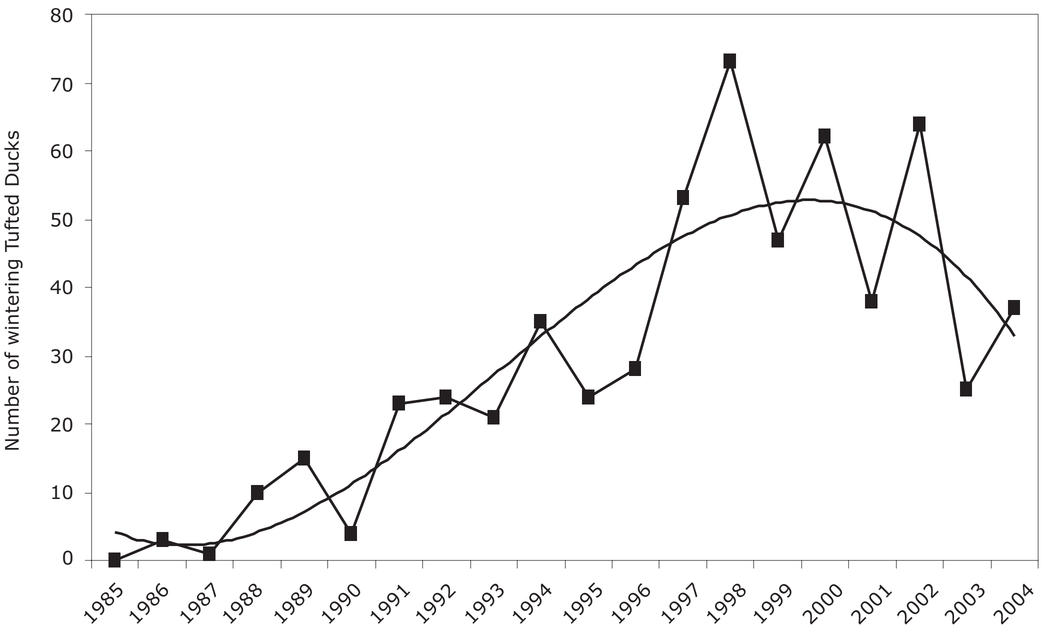

Figure 2. Numbers of wintering Tufted Duck in 1985-2004.
Nombre de morells de plomall hivernants al període 1985-2004.

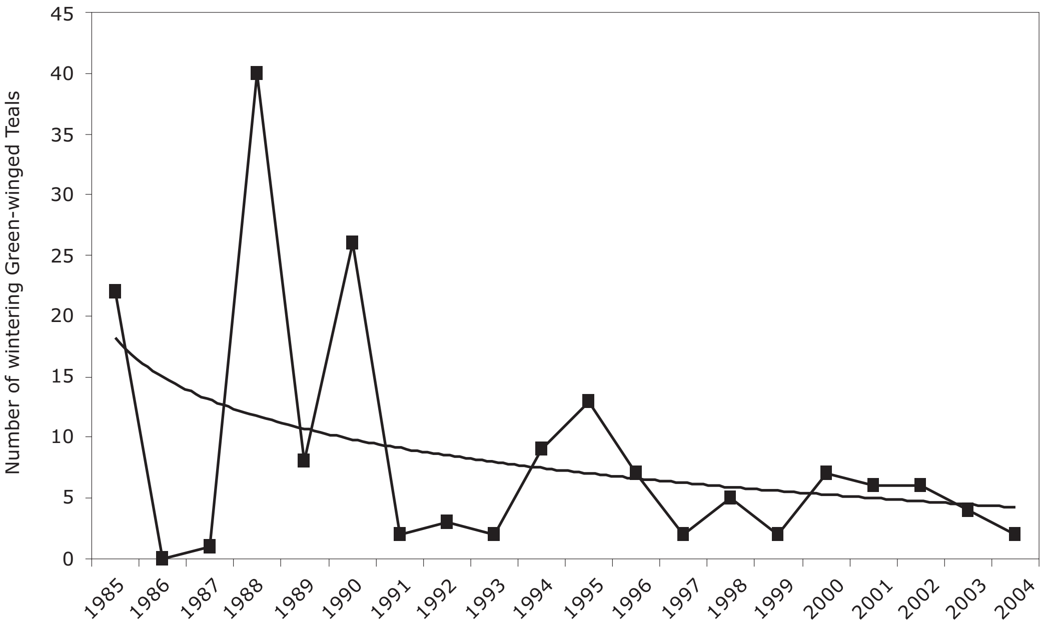

Figure 3. Numbers of wintering Common Teal in 1985-2004.
Nombre de xarxets comuns hivernants al període 1985-2004.

ers; 2) non-freezing segments of small rivers and patches of open water in ponds, totalling about 128 km in length, with many recreation areas along the banks, regularly visited by citizens who feed the birds. More than half of the total number of wintering birds gathered around such feeding places in parks and residential areas. Moscow Zoo was also an important feeding area for the wintering Mallards.

The wintering population of Mallards in the city increased in the period 1985-1990 (r_s=0.83; p<0.05; n=6), reached the maximum in 1989/90, decreased in the period 1990-1998 (r_s=-0.95; p<0.0001; n=9) and increased again from 1999 (r_s=0.96; p<0.001; n=7). In the two major types of water bodies, however, the peaks were observed in different winters (Figure 4). For small rivers and ponds, the peak was the same one as for the whole city (for the periods 1985-1990 and 1990-1998, r_s=0.77; p=0.072; n=6 and r_s=-0.95; p<0.0001; n=9, respectively), whereas at the Moscow River, the maximum number of ducks was counted with a two-year lag (for the periods 1985-1992 and 1992-1998, r_s=0.83; p=0.01; n=8 and r_s=-1.0; p=0.000; n=7, respectively) and resulted in the second, lower peak for the total population. Until 1991, many more individuals were counted at small rivers and ponds than at the Moscow River. Between the winters of 1990/91 and 1991/92, the proportion of Mallards using the two types of water bodies changed. It remained reversed till the winter 1994/95. After 1998, the total number of Mallards increased (r_s=0.95; p<0.01; n=7), especially at the inner water bodies (r_s=0.94; p<0.01; n=7). The increase of the Moscow River group was rather slow (r_s=0.42; ns; n=7). No significant year-to-year changes in the areas of non-freezing water bodies were observed during the study period.

Other species were represented only by a few individuals each, and were recorded in between one and ten winters. Moorhen G*allinula chloropus,* Pochard *Aythya ferina,* Black-necked Grebe *Podiceps nigricollis*, Great Crested Grebe *Podiceps cristatus* and Coot *Fulica atra* were represented in the city by a few birds each. Wigeon *Anas penelope*, Pintail *A. acuta* and Little Grebe *Tachybaptus ruficollis* inhabit Moscow Region, and sometimes visited the city during the study period. Scaup *Aythya marila*, Goosander *Mergus*

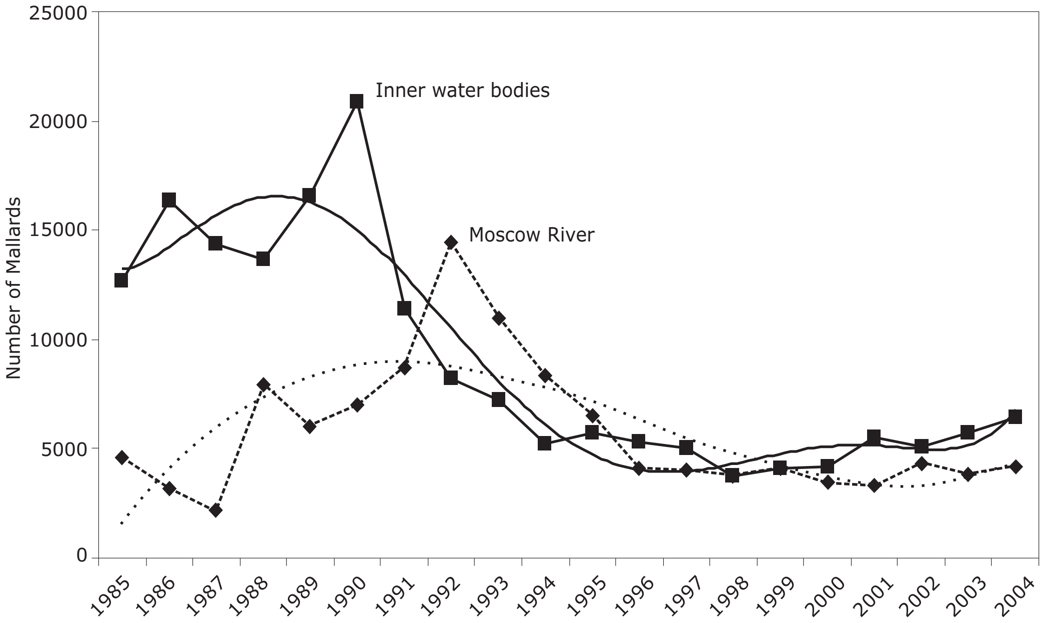

Figure 4. Numbers of wintering Mallard in 1985-2004.
Nombre d'ànecs collverds hivernants al període 1985-2004.

merganser and Smew *Mergus albellus* were regular transient migrants in the Moscow Region, whereas Whooper Swan *Cygnus cygnus* and Cormorant *Phalacrocorax carbo* were occasionally seen. Greylag Goose *Anser anser*, Bar-headed Goose *Anser indicus*, Canada Goose *Branta canadensis*, Common Shelduck *Tadorna tadorna*, Ruddy Shelduck *T. ferruginea*, Muscovy Duck *Cairina moschata*, Red-crested Pochard *Netta rufina* were free-living birds that probably escaped from Moscow Zoo. About 300 Ruddy Shelduck wintering in the Moscow Zoo are offspring of the free-living birds breeding almost exclusively in the city (Popovkina 2003).

During the study period, mean air temperatures in Moscow have increased in January and decreased in November (Figure 5). This means that the weather conditions before winter have become colder but in the course of winter they have become milder. The total species diversity of wintering waterfowl was independent of January air temperature (r_s=0.38; ns; n=20). Among wintering wildfowl, only Mallards showed a significant dependence on climate fluctuations. Two subgroups of the Mallard population displayed a different dependence on air temperature from 1 November to 15 January (MTEW). Birds wintering on the Moscow River near the suburbs of the city depended on weather conditions at two stages of their population dynamics: during the period of increase in 1985-1992 (r=0.81; p=0.01; n=8), and during the period of decline in 1993-1998 (r=0.85; p=0.01; n=7). Mallards wintering on small rivers and ponds of the inner city, including Moscow Zoo, were influenced by air temperature only in the period of population decline in 1991-1998 (r_s=0.78; p=0.02; n=8). Mallards displayed no dependence on MTEW during the second period of increase in 1998-2004 (r_s=0.25; ns; n=7). However, the number of birds wintering on the Moscow River was more closely correlated with MTEW (r_s=-0.51; ns; n=7) than that of birds wintering at small water bodies (r_s=0.25; ns; n=7).

Discussion

The total species diversity of wintering waterfowl in Moscow, and particularly of birds of the order *Anseriformes*, has been continually grow-

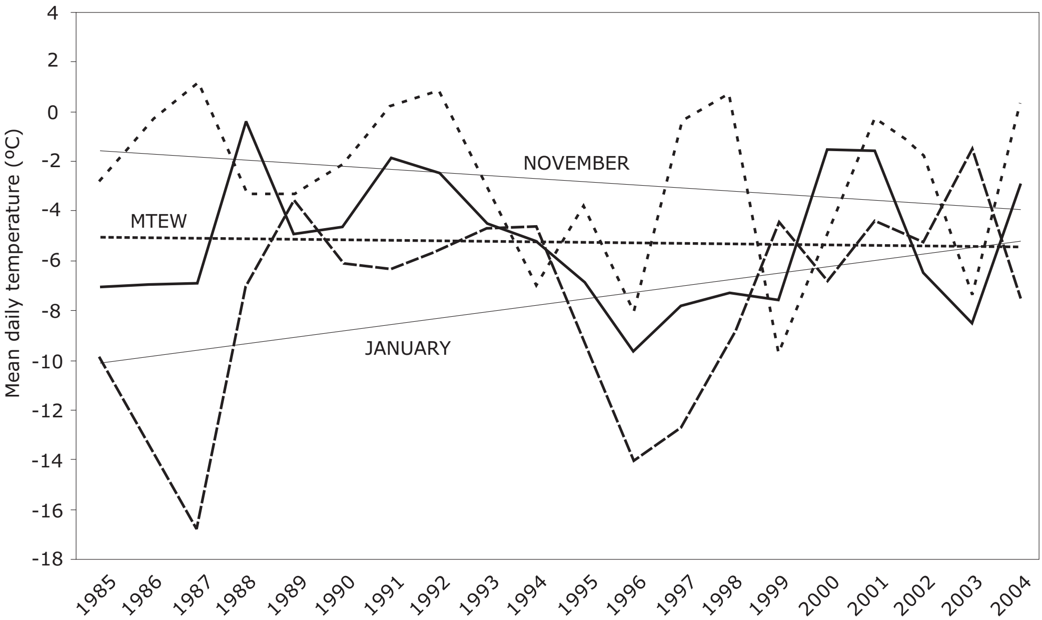

Figure 5. Mean daily air temperature in 1985-2004. MTEW: mean daily air temperature from 1 November of the previous year to 15 January of the given one
Temperatura mitjana de l'aire al període 1985-2004. MTEW és temperatura mitjana de l'aire des de l'1 de novembre de l'any anterior al 15 de gener de l'any de referència.

ing. However, this growth has been independent of the January air temperature. We did not find significant correlations between different species' numbers and mean November or January air temperature. Only MTEW gave significant results. The two subgroups of the Mallard population displayed different associations with air temperature. The size of the group that occupies the Moscow River was more closely correlated with MTEW than that of the group wintering on the inner water bodies of Moscow, including the Zoo. Hence, we may conclude that the first group was composed mainly of migrants and the second by residents, which show a strong dependence on food supplied by city inhabitants (Avilova & Eremkin 2001). Moreover, the dependence on weather conditions of the river subgroup reversed at the stage of the second increase. This may be partly because of the mixing of wild birds with urban Mallards during the period of low population level from 1998 onwards (Figure 4). When the weather becomes colder and urban ponds freeze over, urban ducks fly up to the Moscow River which never freezes over. When the weather warms up, they return to the ponds with numerous wild birds, which join them at the river. Therefore, when temperatures become lower, the number of the Moscow River ducks becomes higher and vice versa.

Common Goldeneye is a rare breeding species in the Moscow Region. A free-living group from the Moscow Zoo began to occupy the study area in the late 1960s, but never wintered here till the early 1990s. Wintering groups of Goldeneye began to form in 1993 and now they are growing quickly (Figure 1). These birds may be partly residents of Moscow and partly seasonal migrants; they depend on native urban food resources, and are not dependent on weather conditions.

Tufted Duck has been a rather numerous breeding species in the Moscow Region since the 1980s, and a small group has wintered at the Moscow River for many years. About 50 Tufted Ducks bred near a Black-headed Gull *Larus ridibundus* colony at the Moscow sewage purification works till their destruction in the middle of 1990s. Since then, the gulls have spread over the city and formed some small colonies at urban ponds and swamps, and the Tufted Ducks continued to nest near them, although most of these colonies have since disappeared. The increase of the wintering Tufted Ducks coincided with the gulls spreading over the city, and the decrease with the gulls' disappearance (Figure 2). All wintering birds were probably Moscow residents. They wintered near their breeding areas and displayed no dependence on air temperature.

Common Teal was a common breeding species in Moscow Region, but some years ago it ceased to breed inside the city. The number of wintering birds has been very low and has slowly decreased during the last decade (Figure 3). A few autumn migrants have joined Mallards or wintered alone.

Conclusion

Numerous urban food resources and mild climate conditions permit waterfowl to be involved in the process of synurbisation and to live in many cities throughout the whole year. However, not all waterfowl species are able to occupy urban water bodies. Their dependence on weather conditions, i.e. on air temperature, can be used as the measure of their urbanisation. Amongst these species, Common Teal has suffered most negatively from the increasing anthropogenic pressure, and it is gradually disappearing from the urban fauna. Tufted Duck, a rather numerous urban species in recent decades, is also decreasing following the decrease in the gull population with which it associates. Common Goldeneye was introduced to the Moscow fauna in the course of an experiment in the 1960s, and is now one of the most successful urban species. Undoubtedly, Mallard is, as elsewhere, the most successful species of urban waterfowl. There are two temporarily independent subgroups ("ecological populations" after Naumov 1975) of Mallards inside the city. Staying separate when numbers are high, they start to mix after the migrant population decreases in size. This can lead to the whole group escaping dependence on weather conditions as the first stage of synurbisation.

Acknowledgements

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Resum

El nombre d'ocells aquàtics hivernants a Moscou (1985-2004) i la seva dependència de les condicions climàtiques

Es van censar els ocells aquàtics hivernants de totes les masses d'aigua de la ciutat de Moscou durant dinou anys (1985-2004). Aquests censos es van realitzar durant el dia a mitjans gener gràcies a la participació de voluntaris i sota la direcció de la *Russian Bird Conservation Union*. El nombre d'espècies va augmentar gradualment al llarg del període d'estudi (r=0,86; p <0,01; n=20) i aquí es mostren les tendències de les quatre principals espècies hivernants (Ànec Collverd *Anas platyrhynchos*, Xarxet Comú *Anas crecca*, Morell d'Ulls Grocs *Bucephala clangula* i Morell de Plomall *Aythya fuligula*). Les poblacions de Xarxet Comú, Morell d'Ulls Grocs i Morell de Plomall no van mostrar cap relació amb les condicions meteorològiques. En canvi, la població d'Ànec Collverd es va associar amb la temperatura de l'aire en determinats períodes i zones. El nombre d'ànecs collverds hivernants al riu de Moscou va mostrar una associació significativa amb les condicions meteorològiques en les primeres etapes estudiades: durant el període d'augment, els anys 1985-1992 (r=0,74; p=0,05; n=8), i durant el període de disminució, els anys 1993-1998 (r=0,88; p=0,01; n=7). Els ànecs collverds que hivernen als petits rius i llacunes interiors de la ciutat van dependre de la meteorologia només en el període de disminució de població, els anys 1991-1998 (r=0,83; p=0,01; n=9). La independència de les condicions climàtiques, com per exemple de la temperatura de l'aire, pot ser utilitzada com una mesura del grau d'urbanització en nombroses espècies d'aus aquàtiques.

Resumen

El número de aves acuáticas invernantes en Moscú (1985-2004) y su dependencia de las condiciones climáticas

Se censaron las aves acuáticas invernantes en todas las masas de agua de la ciudad de Moscú durante diecinueve años (1985-2004). Estos censos se realizaron durante el día a mediados de enero gracias a la participación de voluntarios y bajo la dirección de la

Russian Bird Conservation Union. El número de especies aumentó gradualmente a lo largo del período de estudio (r=0,86; p <0,01; n=20) y aquí se muestran las tendencias de las cuatro principales especies invernantes (Ánade real *Anas platyrhynchos*, Cerceta Común *Anas crecca*, Porrón Osculado *Bucephala clangula* y Porrón Moñudo *Aythya fuligula*). Las poblaciones de Cerceta Común, Porrón Osculado y Porrón Moñudo fueron independientes de las condiciones meteorológicas. En cambio, la población de ánade real se asoció con la temperatura del aire en determinados períodos y zonas. Los ánades reales invernantes en el río de Moscú dependieron de las condiciones meteorológicas en primera etapas estudiadas: durante el período de aumento en 1985-1992 (r=0,74; p=0,05; n=8), y durante el período de disminución en 1993-1998 (r=0,88; p=0,01; n=7). Los ánades reales que invernan en los pequeños ríos y lagunas interiores de la ciudad dependieron de la meteorología sólo en el período de disminución de población, en 1991-1998 (r=0,83; p=0,01; n=9). La independencia de las condiciones climáticas, como por ejemplo de la temperatura del aire, puede ser utilizada como medida del grado de urbanización en numerosas especies de aves acuáticas.

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