

**„Influence of environmental factors on selected properties of the geese *Anser* sp. population during their spring migration and stopover in the northeastern Poland, with a particular consideration of the Biebrza Basin”**

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## **1. Introduction**

The Biebrza Basin is an important area for geese during their spring migration through Poland. These are the long-distance migrants: the dominating Greater White-fronted Goose *Anser albifrons*, for which the area is one of the key stopover sites in the continent, and the less abundant Bean Goose *Anser fabalis (sensu lato)*<sup>1</sup>. Birds stop here on their way from wintering grounds in western and central Europe to breeding sites in the Arctic Russia. The third relatively numerous geese species, and the only one breeding in the Biebrza Basin, is the Greylag Goose *Anser anser*, a short-distance migrant. It was expected that the course of migration and stopover duration in the area will be influenced by various environmental factors, including weather. In the harsh, continental climate of north-eastern Poland, weather conditions can be particularly important, affecting the access to feeding grounds. Climate change was expected to advance the arrival of geese; however, the duration of their staging in the Biebrza Basin can depend on numerous environmental factors and on the features of geese populations, such as age and sex structure. The variables including the onset of spring, access to water and food, presence of birds from different age classes and the impact of the oncoming breeding season, can affect the phenomenon of geese migration in the Biebrza Basin. An attempt at quantifying these interrelations is the subject of the thesis.

## **2. Thesis aim**

The aim of the thesis is to determine the impact of environmental factors on selected properties of the populations of greater white-fronted, bean and greylag geese during their spring migration to breeding sites and staging in the north-eastern Poland. It was expected that for the geese species with different migration phenology, the availability of feeding grounds depends on various factors, including harsh, continental climate conditions in the north-eastern Poland. The assumed effects of such impact and the global warming, were the

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<sup>1</sup> The research was conducted before the taxonomic splitting of the Bean Goose *Anser fabalis sensu lato* into the Taiga Bean Goose *Anser fabalis* and the Tundra Bean Goose *Anser serrirostris* (Stawarczyk 2018). Therefore the two species are discussed together in the thesis under the Bean Goose *A. fabalis sensu lato*. Author's observations and the new literature (Krajewski 2018) indicate that the majority of bean geese *sensu lato* in the Biebrza Basin were the tundra bean geese; in the cited publication their share was estimated at 89.1-98%. It means that in the research described in the thesis the tundra bean goose was much more abundant than the taiga bean goose.

differences in the arrival time of the Arctic geese and the course of their migration. The duration of the presence of geese at the stopover site should be also connected with the approaching breeding season, changing birds' behaviour, depending on their age and sex.

### **3. Methods**

The research was conducted in the Biebrza Basin, including the middle and lower course of the Biebrza River and the Narew River between the inflows of the Supraśl River and the Gać River. The share of main habitat types was calculated on the basis of the Corine Land Cover vector map. Geese preferences with regard to feeding grounds were examined during field observations. The majority of research area was covered with meadows and pastures (28,260 ha, 52.0%), heterogeneous land with mixed crops and arable land had smaller share (13,689 ha, 25.2%), while other habitats covered 22.8% and were not significant for geese. Meteorological data were obtained from the Białystok Weather Station, situated at a distance of 18-60 km from the borders of the research area. Observations of the preferences for particular foraging habitats (arable land vs. meadows and pastures) were carried out for a long-distance migrant – greater white-fronted goose and the short-distance migrant – greylag goose. In 2007-2013 birds were counted once in each ten-day period (decade) in March and April. Habitat preferences of both species were tested with the use of analysis of variance (ANOVA), Akaike's information criterion (AIC) and General Linear Mixed Models (GLMM). The following independent variables were analysed: year, decade, habitat and weather factors – air temperature, precipitation, number of days with snowfall during the previous winter (affecting the extent of flooding in the following spring). Pearson's correlation was used to examine the relationship between the number of geese and selected climatic factors.

In order to assess the impact of weather factors on the migration of greater white-fronted and bean geese, the first arrival date in the macroregion (North Podlasie Lowland) and the relationship between air temperature and ice cover and the number of birds were taken into account. Assuming the possible influence of global warming on the trends in geese arrival in north-eastern Poland, the first arrival dates of greater white-fronted and bean geese from 1996-2015 were correlated with the mean air temperature. It was also used as a predictor variable for the arrival dates of both species. In further analyses, the dynamics of Arctic geese (greater white-fronted and bean) migration in the Biebrza Basin in 2008-2014, based on 210 counts, was presented as the proportion of birds from both species in consecutive 10-day periods from February to May. Spearman's rank correlation was used to test the influence of

mean air temperature on the numbers of birds. During the censuses, observers noted the extent of ice cover in the three classes: 0-33%, 34-66% and 67-100%. The impact of this parameter on the numbers of geese was tested with one-way ANOVA.

It was expected that the greater white-fronted geese stopover duration can be strongly affected by the pressure from the oncoming breeding season and the birds' population features, such as age and sex. To test the relations, records of 1,115 neck-banded birds noted in the Biebrza Basin in March and April 2007-2017 were analysed. Geese were marked in the wintering sites in the Netherlands and Germany and in the breeding and moulting areas in northern Russia, where their age and sex were identified. The records were downloaded from the database geese.org. Statistical analyses were conducted with the use of generalised linear mixed (GLM) model, in which white-fronted geese stopover duration was tested according to birds' age, sex and the date of arrival. Two age categories were distinguished – immature (recorded in spring in the 2<sup>nd</sup> calendar year of life) and older ones (adults). In the case of birds neck-banded in the 1<sup>st</sup> and 2<sup>nd</sup> calendar year, the exact age was known and in some analyses it was treated as a continuous variable.

## **4. Results and discussion**

### **4.1. Differences in the use of foraging habitats by two geese species**

In the first presented paper (Polakowski & Kasprzykowski 2016) foraging habitat preferences of a long-distance migrant – greater white-fronted goose, and the short-distance migrant – greylag goose were analysed. One of the earlier articles (Polakowski et al. 2011) indicated that the two species differ in terms of migration phenology: greylag goose arrives much earlier and the migration ends at the time when there is a peak of white-fronted goose migration. It is probably accompanied by different availability of food resources in the harsh climate conditions of the Biebrza Basin: low air temperature, long lasting snow and ice cover and delayed vegetation season. Therefore, differences in feeding habitat preferences between the two species were expected, depending on the season stage and other variables.

Indeed, the numbers of geese in different habitats varied (Polakowski & Kasprzykowski 2016). Greylag geese were more frequent on arable lands and were recorded earlier in the spring, while the white-fronted geese were feeding on meadows and were seen later in the season. The numbers of greylag geese were influenced by the year, habitat and 10-day period, while for the white-fronted geese, apart from these factors, also the number of days with snowfall in the previous winter and the mean air temperature. To conclude, the

results show the pressure of various factors on the two migrating geese species and the adaptation of their foraging strategies to changeable conditions of spring in the Biebrza Basin.

#### **4.2. Impact of temperature on geese phenology, numbers and course of migration**

The influence of weather conditions on the migration of the white-fronted and bean geese was analysed in the second paper (Polakowski et al. 2018). Climate change was expected to advance the arrival time of both species, reaching their nesting sites in northern Russia faster and starting breeding earlier. Data from the whole North Podlasie Lowland (north-eastern Poland) show that the arrival of first white-fronted and bean geese took place between the 21<sup>st</sup> January and 23<sup>rd</sup> March. The median date for the first species was 28<sup>th</sup> February and for the second one – 1<sup>st</sup> March. In the analysed period of 1996-2015 there was no significant advance in arrival date of both species. It was connected with a very slight increase in mean temperature in spring within the twenty years. However, the mean spring temperature had a significant impact on the first arrival dates of both species, as the conditions were probably better when it was warmer: food, water and roosting sites were more available. In 2008-2014 weather conditions in the Biebrza Basin affected also the course of geese migration. The numbers of both species depended on the mean air temperature, determining the abundance of food and water. The greatest numbers of birds were recorded when the extent of ice cover on the flooded areas was limited and significant differences were noted between the highest and the lowest level of ice cover (Polakowski et al. 2018).

Despite the global climate change, there was no significant advancement of the Arctic geese arrival in the harsh conditions of the north-eastern Poland, probably due to merely a slight increase in temperature noted here within the last 20 years. However, this climate factor was crucial for the course of geese migration, as it determined the access to water and foraging habitats. Temperature also affects the extent of ice cover on flooded areas – geese roosting sites: the highest numbers of individuals were noted when the level of ice cover was the lowest.

#### **4.3. The impact of birds' age, sex and the progress of spring season on the greater white-fronted goose stopover duration**

The research on white-fronted goose stopover duration was possible due to sufficient number of records of birds neck-banded in Western Europe and Russia (Polakowski et al. 2019). The records of 1,115 geese, including 1,029 adults and 86 immature birds (2<sup>nd</sup> calendar year of life), were analysed. 544 records concerned males and 571 – females. Adult birds arrived at the Biebrza Basin earlier and stayed here for shorter periods than immature geese.

Similarly, stopover duration decreased with the progress of migration season and birds' age. This could be the result of a pressure from the oncoming breeding season, hastening adult birds and shortening their stopover in the Biebrza Basin. On the other hand, the differences could be affected by the adults' greater experience and more effective foraging, as well as vegetation growth in the later phase of migration season, enabling faster accumulation of energy.

The longer stopover duration of immature white-fronted geese in the Biebrza Basin can be explained by the lack of pressure from the oncoming breeding season, lower feeding effectiveness and poorer experience. There were no significant differences in the stopover duration among males and females (Polakowski et al. 2019), probably due to the fact that geese often migrate in pairs. Males can be even slowed down by females, feeding to accumulate enough fat for further migration, production and incubation of eggs, as females stay in the nests for the whole incubation period.

In conclusion, birds' age and the progress of migration season affect the white-fronted geese stopover duration in the Biebrza Basin. Particularly, the dominating adult geese are stimulated by various factors: pressure from the breeding season, hastening further migration, as well as greater availability of foraging grounds, enabling more effective accumulation of energy. The duration of geese stopover in the Biebrza Basin is therefore a resultant of endogenic and environmental factors.

## **5. Summary**

Among the environmental factors affecting the properties of geese populations during migration and stopover in the north-eastern Poland, weather conditions seem to be crucial. They influence the availability of foraging and resting sites, which is particularly important in the harsh conditions of early spring in the North Podlasie. The average temperature in the cold, continental climate did not increase significantly over the last years, so that the geese arrival dates did not advance. However, temperature has a major direct and indirect (ice cover) impact on the phenology and course of spring migration. In the earlier phase of the season the species which migrates for shorter distance, *i.e.* the greylag goose, seems to be more effective, while the arrival of Arctic geese takes place in the later, more favourable period.

The pressure from the oncoming breeding season affects the shorter stopover of the most numerous geese species in the Biebrza Basin – the greater white-fronted goose. It concerns the dominating adult birds, which, due to migration anxiety, need to continue their

onward movement to Siberian breeding grounds as soon as possible. Being more effective in foraging, they seem to accumulate energy (fat load) faster. Immature birds are less effective, they are under no such strong time pressure and they stay in the Biebrza Basin for longer time.

## **6. Literature**

### **6.1 Publications in the scope of doctoral thesis**

**Polakowski M., Kasprzykowski Z.** 2016. Differences in the use of foraging grounds by Greylag Goose *Anser anser* and White-fronted Goose *Anser albifrons* at a spring stopover site. *Avian Biology Research* 9, 4: 265-272.

**Polakowski M., Kasprzykowski Z., Goławski A.** 2018. Influence of temperature on the timing of spring arrival and duration of migration in Arctic goose species at a central European stopover site. *Ornis Fennica* 95: 32-40.

**Polakowski M., Jankowiak Ł., Stępniewski K., Stępniewska K., Kruckenberg H., Ebbinge B.S., Broniszewska M., Cichocka A.** 2019. Timing and duration of spring staging of the Eurasian Greater White-fronted Goose (*Anser albifrons albifrons*) in relation to sex, age and progress of migration season. *Ornis Fennica* 96: 24-32.

### **6.2 Additional papers**

Krajewski Ł. 2018. Występowanie gęsi zbożowej *Anser fabalis* i gęsi tundrowej *A. serrirostris* w Kotlinie Biebrzańskiej. *Ornis Polonica* 59: 197-210.

Polakowski M., Broniszewska M., Jankowiak Ł., Ławicki Ł., Siuchno M. 2011. Liczebność i dynamika wiosennego przelotu gęsi w Kotlinie Biebrzańskiej. *Ornis Polonica* 52: 169-180.

Stawarczyk T. 2018. Zmiany taksonomiczne na liście ptaków krajowych według taksonomii IOC. *Ornis Polonica* 59: 71-77.