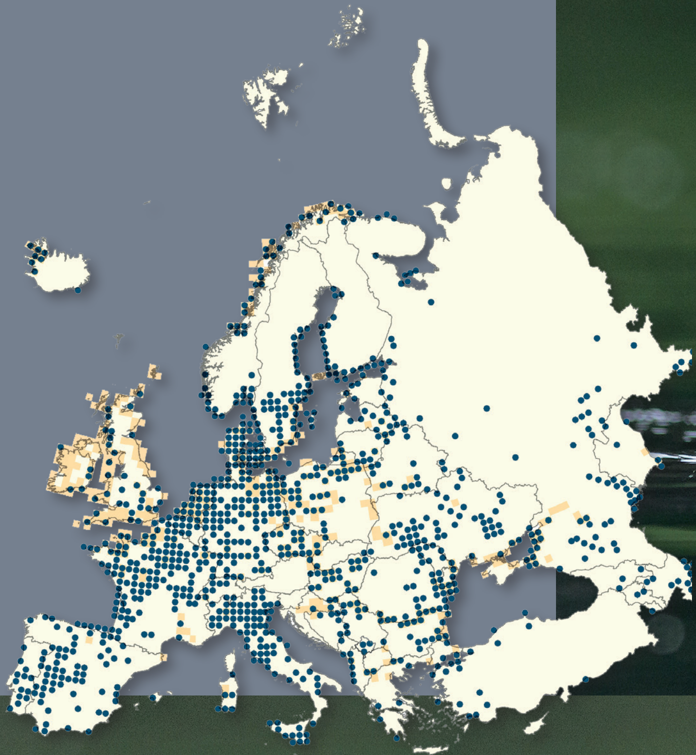
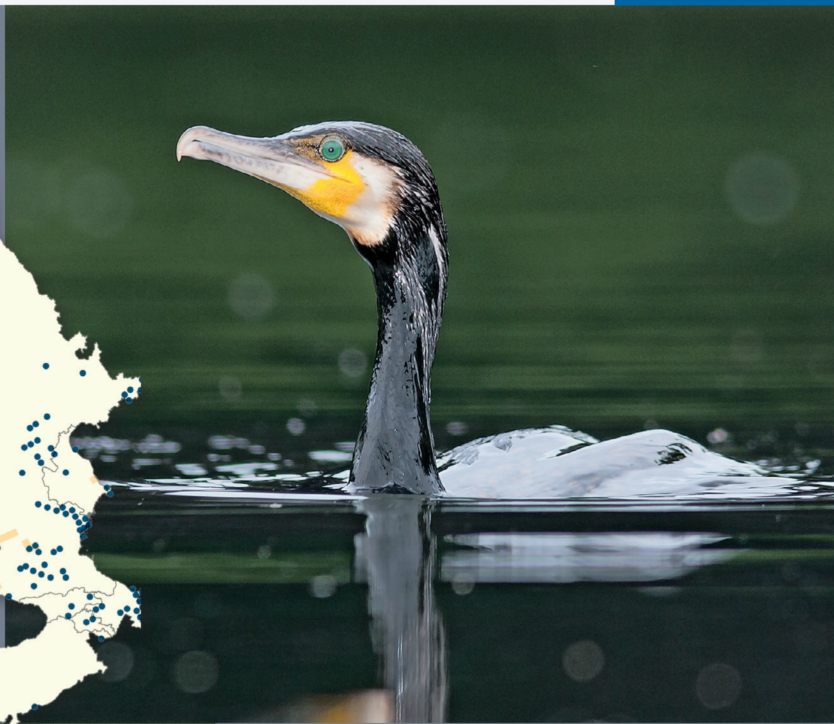
Die Vogelwelt

Beiträge zur Vogelkunde 137. Jahrgang | 2017 Heft 2





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Karte: Pilot map from the European Bird Atlas EBBA2; distribution Great Cormorant; orange = EBBA1, blue = EBBA2 – *Pilotkarte des zweiten Europäischen Brutvogelatlas EBBA2; Verbreitung des Kormorans; orange = EBBA1, blau = EBBA2* © EBCC

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Foreword

We are pleased to present you the second issue of the Proceedings of the 20th International Conference of the European Bird Census Council (EBCC) – Bird Numbers 2016 – held at the Martin-Luther University Halle-Wittenberg in September 2016.

The Proceedings are based on the eight plenary talks, 65 talks, 15 speed talks and about 70 posters presented in frame of the conference and reflect the participation of ornithologists from nearly all European countries including European Russia, as well as attendees from several African countries, from Iran, Israel, USA and even Nepal.

The Proceedings provide an interesting insight into current ornithological assessments and studies in Europe and abroad. This second issue of the Proceedings covers the monitoring of staging and wintering birds, papers on land use impacts and the habitat and distribution of birds. Moreover, single contributions discuss the development of a bird database for countries in West Africa, how young White Storks prepare for their first migration and the development of a forest bird indicator for Austria.

We are very pleased to be able to deliver the Proceedings within only a few months after the conference. This has only been possible due to comprehensive support by the reviewers and the dedicated work of all contributing authors and we would very much like to thank all of them!

Malte Busch, Rainer Dröschmeister,
Kai Gedeon, Christoph Sudfeldt
for the National Organising Committee

Vorwort

Wir freuen uns Ihnen das zweite Heft des Tagungsbands zur 20. Internationalen Konferenz des European Bird Census Councils (EBCC) – Bird Numbers 2016 – präsentieren zu können, die im September 2016 an der Martin-Luther-Universität Halle-Wittenberg in Halle (Saale) stattfand.

Die Beiträge des Tagungsbands basieren auf acht Plenarvorträgen, 65 Vorträgen, 15 Kurzvorträgen und 70 Posterpräsentationen, die im Rahmen der Konferenz präsentiert wurden, und reflektieren dabei die Teilnahme von Ornithologinnen und Ornithologen aus nahezu allen europäischen Staaten inklusive des europäischen Teils Russlands sowie aus verschiedenen afrikanischen Ländern, dem Iran, Israel, den USA und Nepal. Der Tagungsband liefert einen interessanten Überblick über aktuelle ornithologische Auswertungen und Studien in Europa und darüber hinaus. Der hier vorgelegte zweite Band beschäftigt sich insbesondere mit dem Monitoring rastender und überwinternder Vögel, dem Einfluss von Nutzungsänderungen auf die Vogelwelt sowie Beiträgen zu Lebensräumen und zur Verbreitung von Vögeln. Darüber hinaus beleuchten Einzelthemen den Aufbau einer Vogelbeobachtungsdatenbank für Westafrika, wie sich junge Weißstörche auf den ersten Zug in den Süden vorbereiten sowie die Entwicklung eines Waldvogelindikators für Österreich.

Wir freuen uns, den Tagungsband bereits wenige Monate nach Konferenzschluss präsentieren zu können. Dies war nur durch die umfassende Unterstützung der Gutachter/innen und die engagierte Arbeit aller Autor/innen möglich, bei denen wir uns noch einmal sehr herzlich bedanken möchten!

Malte Busch, Rainer Dröschmeister,
Kai Gedeon, Christoph Sudfeldt
für das nationale Organisationskomitee

Thanks to great weather during the entire conference week the poster session became on open air event. – *Wegen sommerlichen Temperaturen während der ganzen Konferenzwoche, konnte die Präsentation der Poster zur Freiluftveranstaltung werden.* Photo: K. Berlin

Long-term woodpecker winter population dynamics in the Tatarstan Republic

Arthur Askeyev, Oleg Askeyev & Igor Askeyev

Askeyev, A., O. Askeyev & I. Askeyev 2017: Long-term woodpecker winter population dynamics in the Tatarstan Republic. Vogelwelt 2017: 130–133.

Few studies have considered the effects of climate change on bird populations at the eastern edge of Europe. Furthermore, there is little information on changes in winter bird populations in this region. During the last 30 years climate change has had a serious impact on ecosystems. A significant increase in both mean annual temperature and in dry periods in the Tatarstan Republic had a negative impact on forest conditions. The number of withering and dying trees in forest stands has increased and, as a result, the number of xylophagous (wood-eating) insects will have increased. The aim of our research was to analyze data on the winter density of woodpeckers to determine whether these changes have affected abundance of these species. Data were collected during the period from 1991 to 2015 using bird censuses based on transect methods. Great Spotted, Grey-headed, Black and Three-toed Woodpecker showed a significant increase in abundance. Winter, summer or annual temperatures affected winter numbers of most woodpecker species. We hypothesize that the main factor influencing population growth is an increase in food availability for Black Woodpecker, Great Spotted Woodpecker, Grey-headed Woodpecker and Three-toed Woodpecker as a result of the withering of trees. Great Spotted Woodpeckers are also strongly influenced by annual seed yield of conifers. Similar increases in woodpeckers have been observed in other parts of Europe, such as Finland, Sweden and Denmark. Thus, climate changes cause rapid responses of forest ecosystems as a whole and of its individual components. Changes in woodpecker abundance could serve as an indicator of forest health.

Keywords: woodpeckers, winter, climate change, Tatarstan Republic.

1. Introduction

Only a few studies have investigated the effects of climate change on bird populations in the eastern edge of Europe (Preobrazhenskaya 2007). Furthermore, there is very little information published on changes to winter bird populations. Eight species of woodpecker live in the Tatarstan Republic (Cramp 1985, Askeyev & Askeyev 1999). All of these play an important role in forest ecosystems, as significant consumers of xylophagous insects and conifer seeds. During the last 30 years, climate change has had a serious impact on ecosystems. A significant increase in mean annual temperature and in dry periods in the Tatarstan Republic has had a negative impact on forest condition. The number of withering and dying trees in forest stands increased and, as a result, also the number of xylophagous insects. The question is whether these changes affect bird populations. The aim of our research was to analyze data on the winter density of woodpeckers, to investigate whether population changes in woodpeckers are correlated with climate, seed production and the proportion of dying trees.

2. Material and methods

Data were collected during the first half of winter (November – December) from 1991 to 2015 in woods and floodplain forests. Bird surveys were made in the morning following Y. S. Ravkin's transect methods (Ravkin 1967); the results were extrapolated to produce numbers per km², based on the mean discovery distances, by the formula:

$$D = \frac{40\,a + 10\,b + 3\,c}{Nkm}$$

where D is the number of individuals per km², a is the number of individuals discovered at a short distance from the observer (up to 25 m), b is the number of individuals in the middle distance (25-100 m), and c is the number of individuals at a far distance (100-300 m). Each year, three researchers surveyed 30-40 fixed randomly-selected plots, covering a total area of 1,000–1,200 square km, the overall length of routes for all years comprising more then 20,000 km. Dynamics of numbers were studied for seven species: Great Spotted Woodpecker *Dendrocopos major,* White-backed Woodpecker *D. leucotos,* Lesser Spotted Woodpecker *Dryobates minor,* Three-toed Woodpecker *Picoides tridactylus,* Grey-headed Woodpecker *Picus canus,* Green Woodpecker *P. viridis* and Black Woodpecker *Dryocopus martius.*

The climate conditions in the preceding months, the abundance of seeds and the numbers of dying or withering

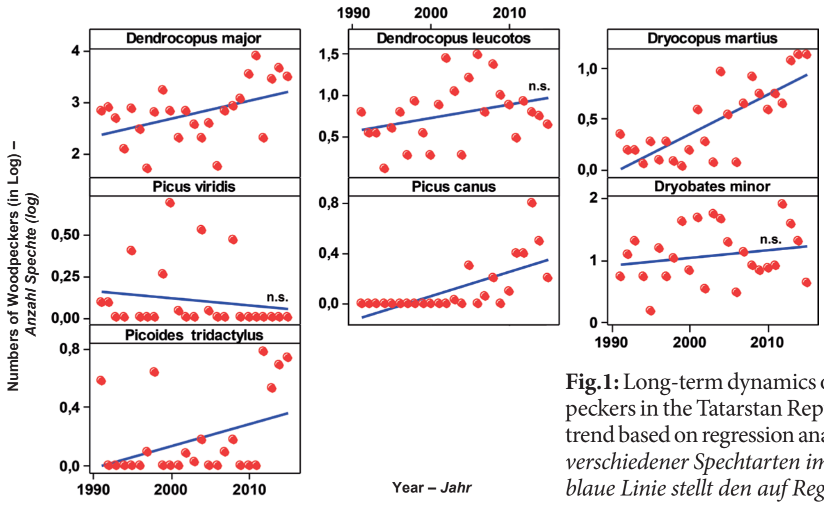

Fig. 1: Long-term dynamics of winter population densities of woodpeckers in the Tatarstan Republic. The blue solid line represents the trend based on regression analysis. – *Langzeitdynamik der Abundanz verschiedener Spechtarten im Winter in der Republik Tatarstan. Die blaue Linie stellt den auf Regressionsanalyse beruhenden Trend dar.*

trees on routes were also recorded. Meteorological data were obtained from five meteorological stations in the Tatarstan Republic. The annual dynamics of bird numbers, the relationship of number of woodpeckers with climate variables, seed production and the proportion of dying trees was estimated by regression methods. All statistical analyses were done in MINITAB 14 and abundance measures log-transformed for analyses.

3. Results and Discussion

There was a large variation in woodpecker species densities in the first half of winter with Great Spotted, Grey-headed, Three-toed and Black Woodpeckers showing a significant increase in abundance between 1991 and 2015 (Fig. 1, Table 1).

Population densities of White-backed and Lesser Spotted Woodpecker also showed a (non-significant) upward trend, but masked by strong annual fluctuations in these species. A (non-significant) reduction in abundance was only found for Green Woodpecker (Fig. 1).

Numbers of four species were related to climate (Table 2). Among measures used in our analyses, the preceding mean winter temperature correlated significantly with abundance of the Black Woodpecker, abundance of Black, Grey-headed and Great Spotted Woodpeckers correlated significantly with annual temperature, and summer temperature had a significant impact on winter numbers of Great Spotted and Three-toed Woodpeckers We did not find any significant relationship between numbers of woodpeckers and temperature in spring or autumn.

The relationships between climatic parameters and the number of woodpeckers have convinced us that climate change is changing the ecosystem. The number of withering and dying trees in forest stands sharply increased in the extremely dry and hot years after 2010, indicated by the point clouds on the right side of the plots shown in Fig. 2, representing post-2010 data. As a result there was an increase in food availability for woodpeckers. In an analysis of the effect of numbers of dying trees on the abundance of the studied species,

Table 1: Changes in woodpecker population density in the first half of winter (numbers per km² ± SE) in the Tatarstan Republic in the study period 1991–2015. Regression coefficients (B ± SE) represent changes in density per year. Significant results are shown in bold. – *Änderungen der Spechtbestandsdichten in der ersten Winterhälfte (Anzahl pro km² ± Standardfehler) der Jahre 1991–2015 in der Republik Tatarstan. Regressionskoeffizienten (B ± Standardfehler) zeigen die Dichteänderungen pro Jahr an. Signifikante Ergebnisse sind fett gedruckt dargestellt.*

Bird species – *Vogelart*	Mean density (ind/ km²) – *mittlere Dichte (Ind./km²)*	Slope of regression – *Steigung der Regression*	
		B	P
Great Spotted Woodpecker – *Buntspecht*	17.6 ± 2.1	**0.030 ± 0.01**	**0.020**
White-backed Woodpecker – *Weißrückenspecht*	1,3 ± 0.18	0.016 ± 0.01	0.110
Lesser Spotted Woodpecker – *Kleinspecht*	2.24 ± 0.3	0.01 ± 0.01	0.360
Three-toed Woodpecker – *Dreizehenspecht*	0.26 ± 0.08	**0.015 ± 0.007**	**0.050**
Black Woodpecker – *Schwarzspecht*	0.7 ± 0.14	**0.04 ± 0.007**	**0.001**
Grey-headed Woodpecker – *Grauspecht*	0.12 ± 0.04	**0.016 ± 0.003**	**0.001**
Green Woodpecker – *Grünspecht*	0.14 ± 0.05	-0.004 ± 0.003	0.440

Table 2: Regression coefficients (slope: B ± SE) from linear regressions between bird densities in the first half of winter and temperatures during the preceding year. NS – non significant. Significant results are shown in bold. – *Regressionskoeffizienten (Steigung: B ± Standardfehler) der linearen Regressionen zwischen Vogeldichten in der ersten Winterhälfte und den Temperaturen des vorangegangenen Jahres. NS – nicht signifikant. Signifikante Ergebnisse sind fett gedruckt.*

Bird species – *Vogelart*	Preceeding Winter T – *Temperatur im vorangegangenen Winter*		Summer T – *Sommertemperatur*		Annual T – *Jahrestemperatur*	
	B ± *SE*	p	B±SE	p	B±SE	p
Great Spotted Woodpecker – *Buntspecht*	NS		**0.17 ± 0.71**	**0.03**	**0.26 ± 0.16**	**0.05**
White-backed Woodpecker – *Weißrückenspecht*	NS		NS		NS	
Lesser Spotted Woodpecker – *Kleinspecht*	NS		NS		NS	
Three-toed Woodpecker – *Dreizehenspecht*	NS		**0.08 ± 0.04**	**0.04**	NS	
Grey-headed Woodpecker – *Grauspecht*	NS		NS		**0.08 ± 0.04**	**0.04**
Green Woodpecker – *Grünspecht*	NS		NS		NS	
Black Woodpecker – *Schwarzspecht*	**0.1 ± 0.04**	**0.02**	NS		**0.27 ± 0.07**	**0.001**

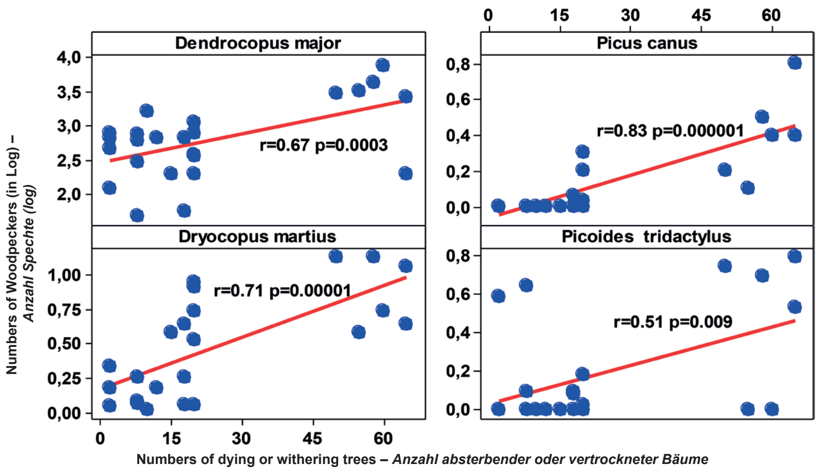

Fig. 2: The relationships between the abundance of four woodpecker species and numbers of withering and dying trees. The red solid line represents the significant relationship between variables based on regression analysis. – *Zusammenhänge zwischen der Abundanz von vier Spechtarten und der Anzahl vertrockneter, absterbender Bäume. Die rote Linie visualisiert den signifikanten Zusammenhang zwischen den Variablen auf Basis einer Regressionsanalyse.*

we found significant positive relationships for Black Woodpecker, Great Spotted Woodpecker, Grey-headed Woodpecker and Three-toed Woodpecker (Fig 2).

In autumn and winter Great Spotted Woodpecker feeds on conifer seeds (Askeyev & Askeyev 1999). We found that one of the main factors that influenced population growth for Great Spotted Woodpecker was seed yield of conifers. High winter population densities of this woodpecker were observed in years with good yields of pine and spruce cones (Fig. 3). Similar results have been shown for southern Finland (Lindén *et al.* 2011) and for the Baltic region and Karelia (Sokolov

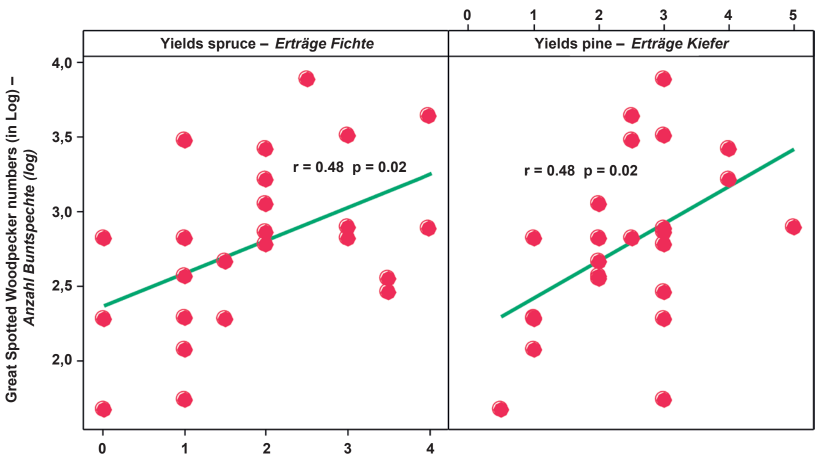

Fig. 3: The relationships between abundance of Great Spotted Woodpecker and conifer cone yields. The green solid line represents the significant relationship between variables based on regression analysis. – *Zusammenhänge zwischen der Abundanz des Buntspechts und der Produktion von Nadelbaumzapfen. Die grüne Linie visualisiert den signifikanten Zusammenhang zwischen den Variablen auf Basis einer Regressionsanalyse.*

et al. 2013). But in other parts of Finland, analaysis of long-term data (1979–95) concluded that the density of this species was not correlated with seed crops of pine or spruce (Saari & Mikusinski, 1996).

In comparing the dynamics of winter numbers of different species of woodpeckers in other northern parts of the European subcontinent, we discovered similarities with our own region. Similar long-term increases for Great Spotted Woodpecker, Grey-headed Woodpecker and Black Woodpecker were observed in Finland (https://rengastus.helsinki.fi/tuloksia/Talvilintulaskenta). In Sweden, a significant increase in numbers of Grey-headed Woodpecker and Three-toed Woodpecker were recorded (Green *et al.* 2016) and in Denmark, a similar increase was observed for Great Spotted Woodpecker (Heldbjerg *et al.* 2013).

We suggest that a combination of factors related to climate change seem to be the primary reason for increasing numbers of some woodpecker species in this period. Thus, climate changes can cause rapid responses in forest ecosystems as a whole and in its individual components. Changes in woodpecker abundance can serve as an indicator of forest health.

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4. Zusammenfassung

Askeyev, A., O. Askeyev & I. Askeyev 2017: Langzeitdynamik der winterlichen Sprechtbestände in der Republik Tatarstan. Vogelwelt 2017: 130–133.

Wenige Studien haben sich bisher mit den Effekten des Klimawandels auf die Vogelpopulationen im äußersten Osten Europas beschäftigt. Zudem gibt es wenige Informationen über die Veränderungen der winterlichen Vogelbestände in dieser Region. In den vergangenen 30 Jahren hatte der Klimawandel erhebliche Auswirkungen auf Ökosysteme. Ein signifikanter Anstieg der mittleren Jahrestemperatur und die Zunahme von Trockenperioden wirken sich negativ auf den Zustand des Waldes in der Republik Tatarstan aus. Die Anzahl vertrockneter und absterbender Bäume in den Wäldern nahm deutlich zu und in Folge wird auch die Anzahl holzfressender Insekten zugenommen haben. In diesem Kontext analysiert der Artikel Daten zur winterlichen Spechtdichte, um zu ermitteln ob diese Veränderungen die Abundanz dieser Arten beeinflusst hat. Die Vogeldaten für die Periode 1991-2015 wurden mit Hilfe von Transekterfassungen gesammelt. Buntspecht, Grauspecht, Schwarzspecht und Dreizehenspecht zeigen einen signifikanten Anstieg der Abundanz. Sowohl Wintertemperaturen, als auch Sommer- sowie Jahrestemperaturen scheinen die Anzahl der meisten Spechtarten im Winter zu beeinflussen. Es wird angenommen, dass der beobachtete Bestandsanstieg bei Schwarz-, Bunt-, Grau- und Dreizehenspecht auf die erhöhte Nahrungsverfügbarkeit durch vertrocknete Bäume zurückzuführen ist. Der Buntspecht wird zudem stark vom jährlich schwankenden Angebot an Nadelbaumzapfen beeinflusst. Ähnliche Bestandszunahmen bei Spechten wurden auch in anderen Teilen Europas, wie Finnland, Schweden und Dänemark beobachtet. Somit scheint der Klimawandel kurzfristig Reaktionen von ganzen Waldökosystemen, als auch einzelner Komponenten dieser Ökosysteme, hervorzurufen. Die Veränderungen der Abundanz von Spechtarten könnte als geeigneter Indikator für den Gesundheitszustand von Wäldern herangezogen werden.

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Bird winter population dynamics at the eastern edge of Europe

Oleg Askeyev, Arthur Askeyev & Igor Askeyev

Askeyev, O., A. Askeyev & I. Askeyev 2017: Bird winter population dynamics at the eastern edge of Europe. Vogelwelt 137: 134–142.

Since the 1970s, the climate in Europe has undergone rapid changes, with the greatest observed changes occurring during the winter. Significant changes in winter conditions have also been observed in the majority of Russian regions. However, in our view, the role played by increases in winter temperature in the dynamics of bird populations is still poorly known. The aim of our research was to analyze data on the winter density of 10 largely sedentary bird species. The material for our research was bird censuses collected using transect counts during a 25 year period from 1991 to 2015. Great Tit, Blue Tit, Willow Tit, Marsh Tit, Crested Tit, Nuthatch, Treecreeper and Goldcrest showed a significant increase in abundace. None of the 10 species showed a decrease in abundance. The main factors correlated with population growth were increases in annual temperature, winter temperature and temperature during the preceding breeding season. In Finland and Sweden, similar abundance dynamics have been observed for some of these species but population trends for Willow Tit, Goldcrest and Crested Tit in this study differed markedly from observations in other parts of Europe. This suggests that climatic changes can have a rapid impact on the size of bird populations and that population trends observed in Eastern Europe may differ significantly from those in the western part of the continent. The inclusion of data on population dynamics from a larger sample of European regions would help to more accurately assess the response of birds to climate change.

Keywords: winter bird density, changes, temperature, European Russia

1. Introduction

Since the 1970s, the climate of Europe has undergone rapid change with the greatest observed change occurring during winter. The temperature trend in the Northern Hemisphere remains strongly positive (IPCC 2014). Recent climate models predict that global temperatures will continue to rise over the current century and these changes will be most pronounced in northerly latitudes (Meehl *et al.* 2007). Winter is the critical season in the life of most living organisms inhabiting temperate and boreal latitudes and one of the factors that directly affects the dynamics of bird populations in these latitudes is winter survival, which in many respects depends on the prevailing temperature. For example, recent research suggests that gene flow in Great Tits *Parus major* may be regulated by environmental factors via movements related to winter severity (Lemoine *et al.* 2016). By the end of the 20th century traditional winters characterized by long periods of snow and temperatures well below zero were no longer a feature of most countries in western and Central Europe. Even in Scandinavia, winters have become markedly milder. Major changes in winter conditions have also been observed throughout much of Russia. However, in our view, the role played by increased winter temperature on the dynamics of bird communities is still poorly known.

Long-term monitoring of bird populations can help answer these questions, and such schemes have successfully operated for many years in Europe and North America. Although the study of population dynamics is often limited to the breeding period, the most valuable datasets are those that monitor birds not only in the breeding season, but also in other seasons, particularly winter, the importance of which to sedentary populations of birds has been noted above. Thus, for understanding the response of bird communities to rising temperature, monitoring is also required in winter, as in studies conducted in Finland (Fraixedas *et al.* 2015, Lehikoinen *et al.* 2016), Sweden (Green *et al.* 2016), Denmark (Heldbjerg *et al.* 2013) and the USA (Prince & Zuckerberg 2015). Analysis of the data permits a number of conclusions about changes of ecosystems on bird communities, including the effect of rising winter air temperature.

However, in a number of regions there is a lack of information on the seasonal and long-term population dynamics of birds, which can lead to inaccuracies in broader assessments of changes in bird communities, and in predictive models. For example, in Europe the majority of studies on long-term dynamics of birds have been in western Europe, while in large areas of eastern

Europe, including Russia, the intensity of such work is much lower (Preobrazhenskaya 2007). Study of bird populations in the non-breeding period in the Russian Federation has been conducted almost exclusively at banding (ringing) stations, primarily on the Baltic coast in the Kaliningrad region. Given the differences in geographic location and human impact (e. g. intensification of forest and agricultural management), bird population trends in eastern Europe may differ significantly from those observed in western Europe (Sokolov *et al.* 2001). The inclusion of data on the dynamics of bird communities from a larger number of regions would help to more accurately judge the birds' response to climate change and other environmental factors at broader geographic scales, and contribute to the development of the most appropriate environmental policies.

In the Tatarstan Republic within the Russian Federation we have collected data on bird populations since 1991. Tatarstan is located in the extreme east of the European plain. As in most of northern Eurasia, this area recorded a significant increase in mean annual air temperature during the second half of the 20th century. At the same time, declines in agriculture and industry reduced the anthropogenic pressure on the environment in Tatarstan. Thus, climate change is not accompanied by other anthropogenic changes, unlike countries in western and Central Europe where the rapid development of agriculture and forestry has led to large-scale environmental change. In our opinion, the geographical remoteness from traditional regions of study, combined with low ecosystem disturbance, makes these data particularly valuable for the study of population dynamics in birds. The aim of this study was to analyze the data collected over a 25-year period on the numbers of 10 species of birds in winter at the eastern edge of Europe. Our main objective was to demonstrate the influence of climatic factors on bird numbers. The hypotheses are that: 1) population dynamics of the studied bird species in winter are largely dependent on climatic factors; 2) the population trends in eastern Europe, including Tatarstan, differ from those in western and Central Europe; 3) in Tatarstan, current climate change leads to growth, rather than reductions, of populations of wintering birds.

2. Material and methods

2.1 Study area and environment

The Tatarstan Republic is located in the extreme east of Europe and lies within 53.58-56.40° N and 47.50-54.00° E. Traditionally, this area is considered in the historical-geographical provinces of European Russia - the Middle Volga and PreUral region. This region covers c. 68,000 km², and includes two natural zones – forest and forest-steppe with various habitats (sub-taiga coniferous deciduous mixed forests, broad-leaved woods, farmland, steppe landscapes, rivers, lakes, and town and villages). Forest covers c.20 % and the relief is mostly flat or undulating lowland with hills (53–382 m a.s.l). The continental climate of the region is typical of eastern Europe. The average annual temperature is c. 2 to 5 °C and monthly mean temperatures range from -12 to -14 °C in January to 19 to 21 °C in July. The lowest temperature recorded in the last 200 years was (-52 °C), and the maximum 40 °C. Average annual precipitation is c. 500–550 mm and snow cover lies for 140–170 days.

2.2 Bird numbers data

Twenty five years of data on bird numbers in winter (from 1st November to 5th March, 1991–2016) were analysed. Bird surveys were done in the morning according to Y. S. Ravkin's transect methods (Ravkin 1967); and counts used to estimate numbers per km², based on the mean detection distances, by the formula:

$$D = \frac{40\,a + 10\,b + 3\,c}{Nkm}$$

where D - the number of individuals per km², a - the number of individuals discovered at a short distance from the observer (up to 25 m), b - the number of individuals in the middle distance (25-100 m), and c - the number of individuals at a further distance (100-300 m). The censuses were carried out in woods and floodplain forests. Three researchers worked on fixed randomly selected plots, to ensure no biases, each year covering 30-40 plots with a total area of 1000-1200 km². Over all years the total length of routes walked was more than 38,000 km. On 60 % of routes the bird counts were conducted monthly, and were bimonthly on the remainder.

2.3 Data analysis

Dynamics of numbers are studied for 10 mainly sedentary species: Great Tit, Blue Tit *Parus caeruleus*, Willow Tit *P. montanus*, Marsh Tit *P. palustris,* Coal Tit *P. ater,* Long-tailed Tit *Aegithalos caudatus,* Nuthatch *Sitta europaea*, Treecreeper *Certhia familiaris*, Goldcrest *Regulus regulus* and Crested Tit *Parus cristatus*. All these species regularly occur in mixed flocks during winter and accordingly good data were available for this species assemblage. Data were log-transformed prior to anlaysis.

We divided winter into two periods – the first half of winter (daylength decreasing), and the second half (daylength increasing) for calculating bird numbers. In the analysis of the influence of climatic parameters on bird numbers, we examined the influence of annual and seasonal air temperature for winter (November – February), spring (before breeding period: March – April), summer (breeding season: May – July), and autumn (autumn migration: August - October) using regression methods. The climate data were obtained from five meteorological stations in Tatarstan. All statistical analyses were done in MINITAB 14.

3. Results

3.1 Temperature

During the study period, mean annual temperatures in the Kazan region of Tatarstan varied widely from 3.3 to 6.3 °C (Fig. 1), with a significant increase (0.067 °C yr^{-1}; Table 1) equating to 1.68 °C over 25 years. The most significant changes in seasons were warming in summer and autumn (Fig. 1, Table 1). The warming in summer

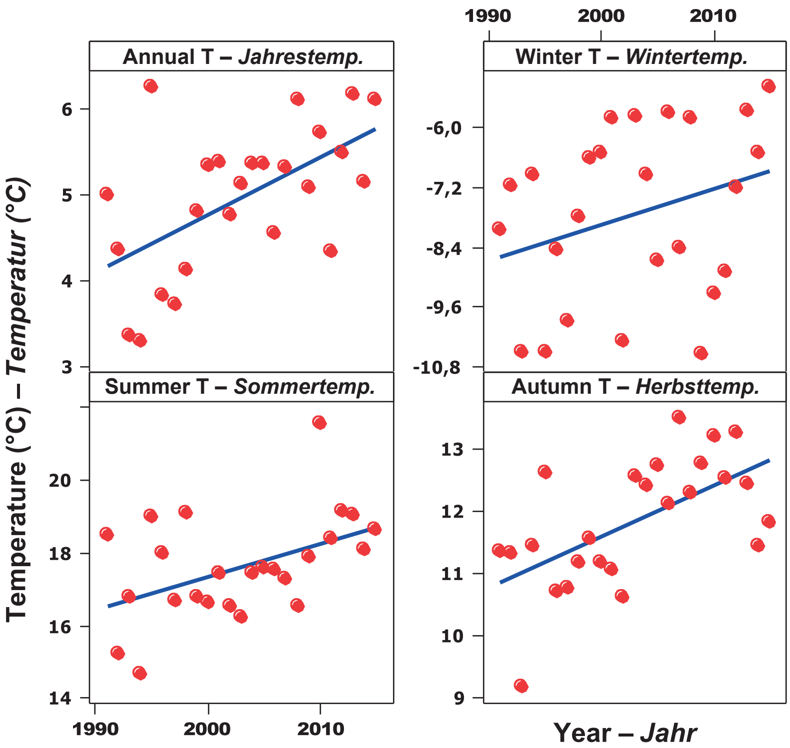

Fig. 1: Temperature changes in Kazan in the study period 1991–2015. Blue solid line represents the trend based on regression analysis. – *Veränderungen der Temperatur in Kazan während des Untersuchungszeitraums 1991-2015. Die blaue Linie stellt den auf Regressionsanalyse beruhenden Trend dar.*

(Fig. 1) was very notable, equating to a temperature increase of 2.2 °C over 25 years. During the study period, the start of permanent snow cover varied widely from 28th October to 19th December (Fig. 2), with a significant delay over time (1.03 days yr^{-1}) equating to 25.5 days over 25 years. This is a good illustration of the trend to a later start of winter.

3.2 Species density

During the first half of the winter, there were large changes in bird densities over time (Fig. 3) and eight species showed significant long-term trends towards increasing numbers (Table 2). Only Coal Tit and Long-tailed Tit did not change significantly.

As in the early winter, bird densities in the second half of winter also changed markedly over 25 years (Fig. 4) five species increasing significantly (Table 3). As in the early winter there were no significant decreases in bird numbers over this period.

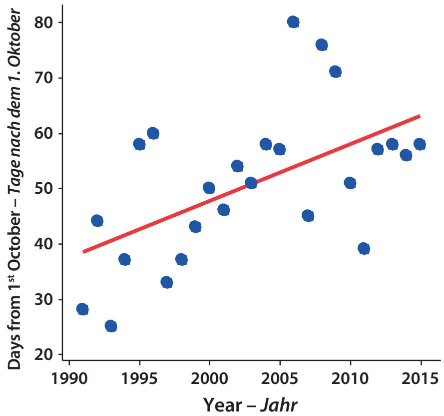

Fig. 2: Long-term dynamics of permanent snow cover in Kazan region. Red solid line represents the trend based on regression analysis. – *Langzeitdynamik permanenter Schneebedeckung in der Region Kazan. Die rote Linie stellt den auf Regressionsanalyse beruhenden Trend dar.*

Table 1: Temperature changes in Kazan 1991–2015. Mean temperature ± SD for seasonal periods and annually are presented, Regression coefficients (B ± SE) represent changes (°C) per year. – *Veränderungen der Temperatur in Kazan 1991-2015. Mittlere Temperatur ± Standardabweichung je Jahreszeit und für das ganze Jahr, Regressionskoeffizienten (B ± Standardfehler) repräsentieren die Änderungen (°C) pro Jahr.*

Period – *Periode*	Mean temperature – *mittlere Temperatur* (°C)	Slope of regression – *Steigung der Regression*	
		B	P
Winter – *Winter*	-7.7 ±1.77	0.075 ± 0.048	0.128
Spring – *Frühling*	1.1 ±1.68	0.021 ± 0.047	0.229
Summer – *Sommer*	17.6 ±1.43	**0.089 ± 0.036**	**0.020**
Autumn – *Herbst*	11.8 ±1.0	**0.082 ± 0.022**	**0.002**
Annual – *jährlich*	4.96 ±0.8	**0.067 ± 0.020**	**0.003**

Table 2: Changes in bird populations in the first half of winter (numbers per km² ± SD) in Tatarstan, 1991–2015. Regression coefficients (B ± SE) represent changes in density per year. Data were log (x+1) transformed prior to analysis. – *Populationsveränderungen in der ersten Winterhälfte (Anzahl pro km² ± Standardabweichung) in der Republik Tatarstan, 1991-2015. Regressionskoeffizienten (B ± Standardfehler) bilden jährliche Änderungen der Dichte ab. Die Daten wurden vor der Analyse log (x+1) transformiert.*

Species – *Art*	Mean Density (ind./km²) – *mittlere Dichte (Ind./km²)*	Slope of regression – *Steigung der Regression*	
		B	P
Great Tit – *Kohlmeise*	44.3 ± 28.4	**0.050 ± 0.019**	**0.010**
Blue Tit – *Blaumeise*	13.9 ± 6.3	**0.027 ± 0.011**	**0.027**
Willow Tit – *Weidenmeise*	52.0 ± 27.1	**0.038 ± 0.010**	**<0.001**
Marsh Tit – *Sumpfmeise*	13.2 ± 9.2	**0.078 ± 0.016**	**<0.001**
Coal Tit – *Tannenmeise*	31.5 ± 23.6	0.054 ± 0.027	0.060
Long-tailed Tit – *Schwanzmeise*	43.6 ± 29.9	0.039 ± 0.020	0.067
Nuthatch – *Kleiber*	20.0 ± 8.8	**0.032 ± 0.012**	**0.010**
Treecreeper – *Waldbaumläufer*	15.3 ± 10.0	**0.040 ± 0.015**	**0.015**
Goldcrest – *Wintergoldhähnchen*	27.4 ± 10.0	**0.045 ± 0.016**	**0.012**
Crested Tit – *Haubenmeise*	4.4 ± 5.2	**0.078 ± 0.022**	**0.001**

To test whether climate had influenced bird numbers, we first conducted an analysis of the effect of temperature in the previous winter, spring, summer and autumn on the populations of the studied species in the first half of the winter. Nearly all species showed significant relationships between the number during this period and temperatures during some seasons in the preceding year. Interestingly, we did not observe any significant relationships between the number of birds in this period with preceding spring and autumn temperatures. In contrast, we found significant positive relationships between early winter bird densities and both the previous winter and summer temperature (Table 4). We also found a strong significant relationship between densities of eight species in this period and annual temperatures (Table 4, Fig. 5). Interestingly, eight species displayed a significant positive relationship with the date of the start of permanent snow cover (meaning that the later the winter started, the more birds were observed), only Blue Tit and Crested Tit were not significant (Fig. 6).

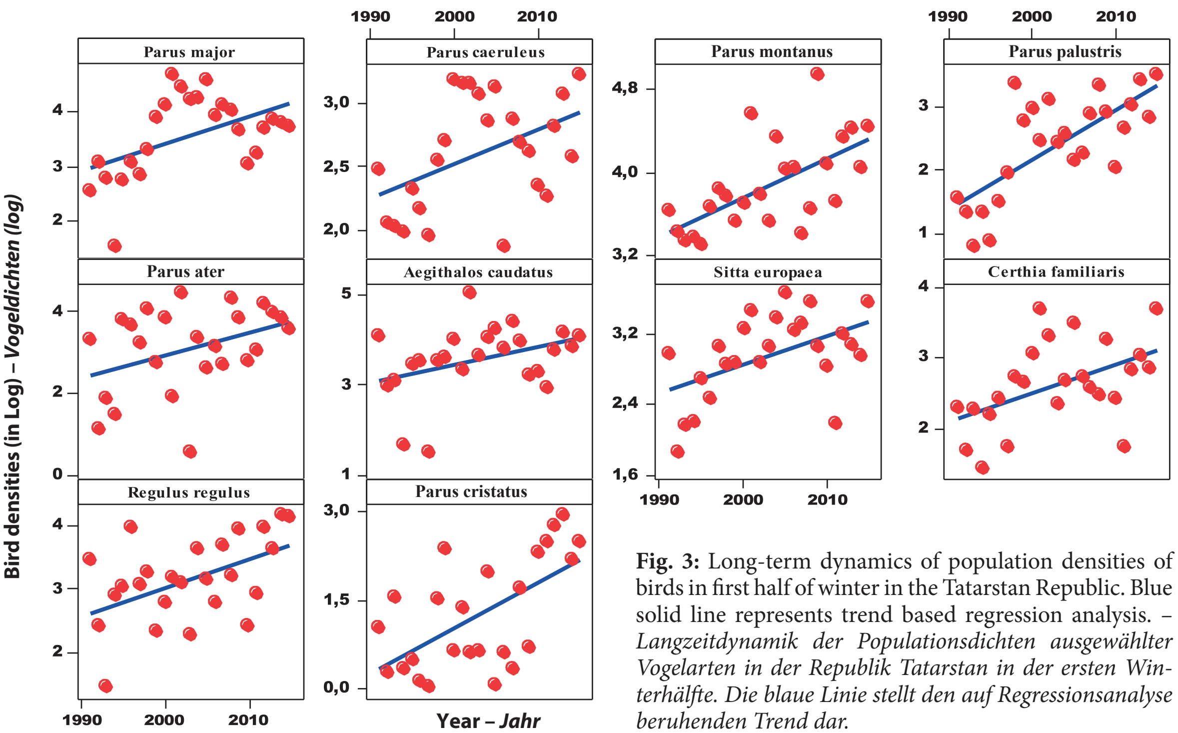

Fig. 3: Long-term dynamics of population densities of birds in first half of winter in the Tatarstan Republic. Blue solid line represents trend based regression analysis. – *Langzeitdynamik der Populationsdichten ausgewählter Vogelarten in der Republik Tatarstan in der ersten Winterhälfte. Die blaue Linie stellt den auf Regressionsanalyse beruhenden Trend dar.*

Table 3: Changes in bird populations in the second half of winter (numbers per km² ± SD) in Tatarstan 1991–2015. Regression coefficients (B ± SE) represent changes in density per year. Data were log (x+1) transformed prior to analysis. – *Populationsveränderungen in der zweiten Winterhälfte (Anzahl pro km² ± Standardabweichung) in der Republik Tatarstan, 1991-2015. Regressionskoeffizienten (B ± Standardfehler) bilden jährliche Änderungen der Dichte ab. Die Daten wurden vor der Analyse log (x+1) transformiert.*

Species – *Art*	Mean Density (ind./ km²) – *mittlere Dichte (Ind./km²)*	Slope of regression – *Steigung der Regression*	
		B	P
Great Tit – *Kohlmeise*	40.4 ± 27.3	0.027 ± 0.021	0.211
Blue Tit – *Blaumeise*	9.4 ± 5.2	0.014 ± 0.015	0.364
Willow Tit – *Weidenmeise*	33.5 ± 19.9	**0.062 ± 0.019**	**0.003**
Marsh Tit – *Sumpfmeise*	11.6 ± 6.8	**0.032 ± 0.016**	**0.050**
Coal Tit – *Tannenmeise*	11.6 ± 11.2	**0.070 ± 0.029**	**0.022**
Long-tailed Tit – *Schwanzmeise*	28.1 ± 17.2	0.039 ± 0.031	0.220
Nuthatch – *Kleiber*	14.4 ± 5.8	0.010 ± 0.013	0.470
Treecreeper – *Waldbaumläufer*	6.6 ± 4.3	**0.036 ± 0.017**	**0.046**
Goldcrest – *Wintergoldhähnchen*	14.1 ± 10.4	0.029 ± 0.024	0.240
Crested Tit – *Haubenmeise*	2.6 ± 4.1	**0.070 ± 0.020**	**0.002**

We found highly significant positive correlations between densities in the first and second halves of the winter for nine species (Table 5); the exception being Blue Tit.

We think the results presented in Table 5 show once again that bird density in the second half of winter is primarily determined by the conditions during the seasons of the preceding year, and bird density in the first half of the respective winter. The higher the number of birds in the first half of the winter the higher it is in the second half. However, severity of winter conditions in the second half of winter appears to determine the population level of birds during this period. For example, densities of Blue Tit, Long-tailed Tit and Goldcrest in late winter had significant relationships with winter temperature in that year (Table 6). For two species, we also found a highly significant negative relationship between numbers in the second half of winter and winter severity, defined as the number of days with temperature below -25 °C (Fig. 7). In severe winters, lower densities of Marsh Tit, Blue Tit, Long-tailed Tit and Goldcrest were observed in late winter.

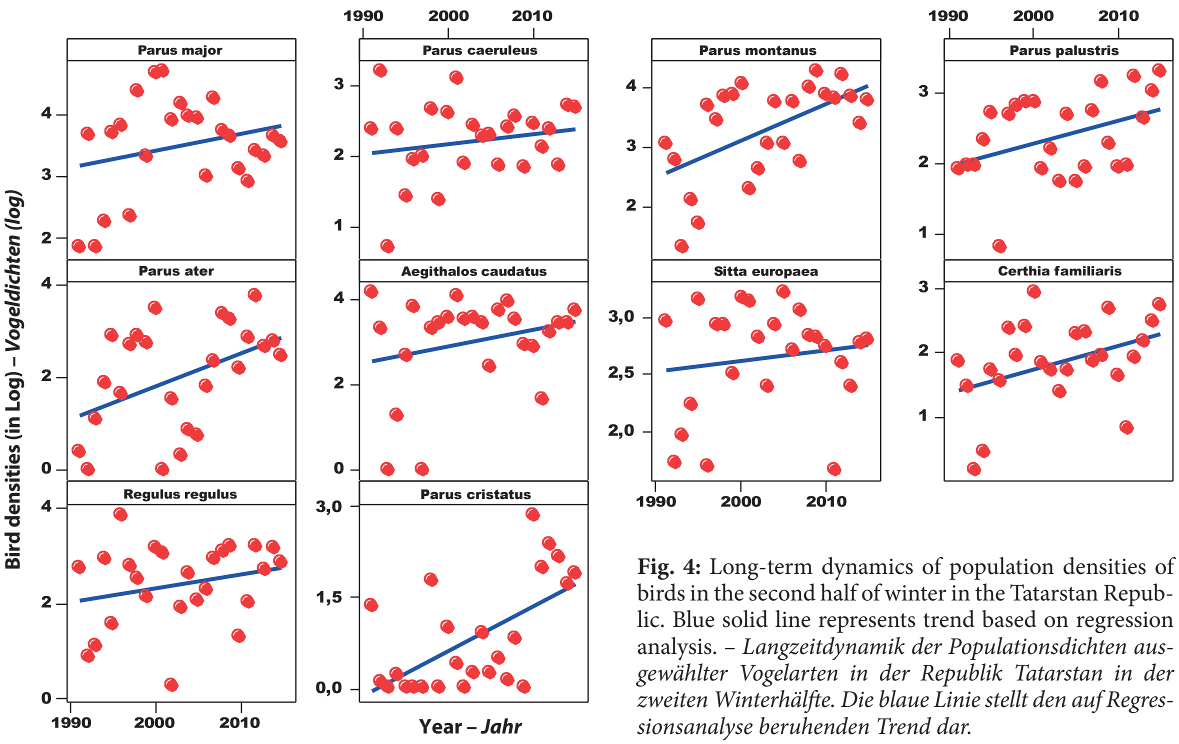

Fig. 4: Long-term dynamics of population densities of birds in the second half of winter in the Tatarstan Republic. Blue solid line represents trend based on regression analysis. – *Langzeitdynamik der Populationsdichten ausgewählter Vogelarten in der Republik Tatarstan in der zweiten Winterhälfte. Die blaue Linie stellt den auf Regressionsanalyse beruhenden Trend dar.*

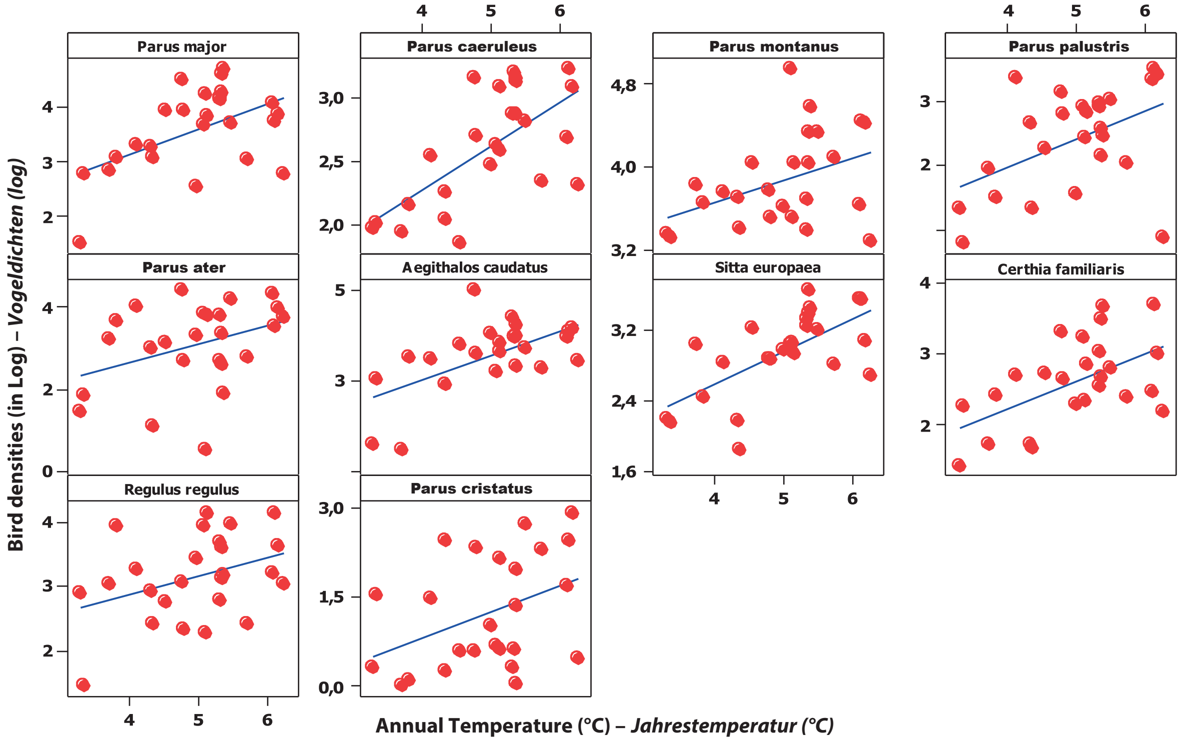

Fig. 5: The relationships between abundance of ten species in the first half of winter and annual temperature. Blue solid line represents relation between variables based on regression analysis. – *Zusammenhänge zwischen der Abundanz von zehn Arten in der erster Winterhälfte und der Jahrestemperatur. Die blaue Linie stellt den auf Regressionsanalyse beruhenden Trend dar.*

Table 4: Regression coefficients (slope: B ± SE) from linear regressions between bird densities in the first half of winter and temperatures during each season of the preceding year. – *Regressionskoeffizienten (Steigung: B ± Standardfehler) der linearen Regressionen zwischen Vogeldichten in der ersten Winterhälfte und Temperaturen aller Jahreszeiten des vorangegangenen Jahres.*

Species – *Art*	Winter T in previous year – *Wintertemperatur im vorangegangenen Jahr*		Spring T – *Frühlingstemperatur*		Summer T – *Sommertemperatur*		Autumn T – *Herbsttemperatur*		Annual T – *Jahrestemperatur*	
	B ± SE	p	B ± SE	p	B ± SE	p	B ± SE	p	B ± SE	p
Great Tit – *Kohlmeise*	**0.22 ± 0.08**	**0.014**	0.12 ± 0.09	0.21	0.01 ± 0.11	0.90	0.19 ± 0.15	0.23	**0.46 ± 0.16**	**0.008**
Blue Tit – *Blaumeise*	**0.13 ± 0.05**	**0.016**	0.08 ± 0.05	0.14	0.03 ± 0.07	0.60	0.12 ± 0.09	0.20	**0.34 ± 0.08**	**0.001**
Willow Tit – *Weidenmeise*	0.08 ± 0.05	0.118	0.01 ± 0.01	0.91	**0.13 ± 0.06**	**0.04**	0.13 ± 0.09	0.16	**0.21 ± 0.10**	**0.046**
Marsh Tit – *Sumpfmeise*	0.12 ± 0.1	0.233	0.07 ± 0.06	0.48	0.11 ± 0.11	0.35	0.26 ± 0.16	0.10	**0.44 ± 0.17**	**0.018**
Coal Tit – *Tannenmeise*	0.18 ± 0.12	0.162	0.17 ± 0.12	0.18	**0.34 ± 0.13**	**0.02**	0.11 ± 0.21	0.61	0.45 ± 0.23	0.07
Long-tailed Tit – *Schwanzmeise*	**0.22 ± 0.08**	**0.014**	0.13 ± 0.09	0.18	0.14 ± 0.11	0.21	0.18 ± 0.16	0.25	**0.54 ± 0.15**	**0.002**
Nuthatch – *Kleiber*	**0.11 ± 0.05**	**0.047**	0.09 ± 0.05	0.10	0.07 ± 0.07	0.30	0.19 ± 0.11	0.06	**0.36 ± 0.09**	**0.001**
Treecreeper – *Waldbaumläufer*	**0.20 ± 0.06**	**0.004**	0.06 ± 0.04	0.38	0.12 ± 0.09	0.16	0.06 ± 0.13	0.64	**0.38 ± 0.12**	**0.005**
Goldcrest – *Wintergoldhähnchen*	0.12 ± 0.08	0.130	0.03 ± 0.02	0.70	**0.15 ± 0.07**	**0.05**	0.22 ± 0.13	0.10	0.29 ± 0.15	0.07
Crested Tit – *Haubenmeise*	0.02 ± 0.02	0.896	0.03 ± 0.02	0.81	**0.35 ± 0.12**	**0.007**	0.20 ± 0.19	0.32	**0.44 ± 0.21**	**0.05**

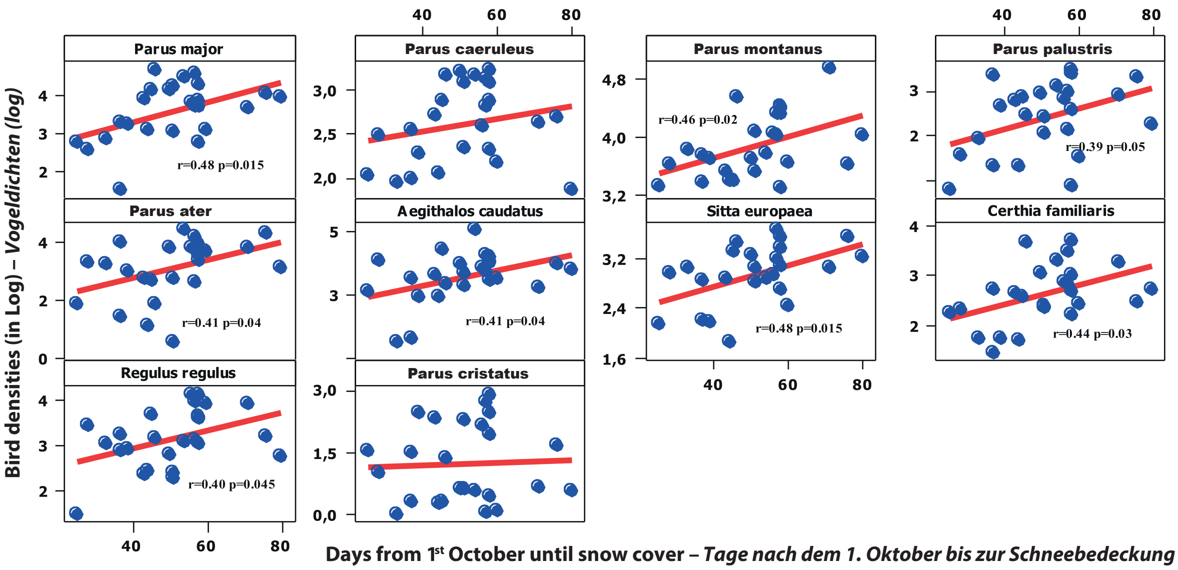

Fig. 6: The relationships between abundance of 10 species in the first half of winter and start date of permanent snow cover. Red solid line represents relation between variables based on regression analysis. – *Zusammenhänge zwischen der Abundanz von 10 Arten in der erster Winterhälfte und dem Datum hab dem eine permanente Schneebedeckung herrschte. Die rote Linie stellt das auf Regressionsanalyse beruhende Verhältnis zwischen den Variablen dar.*

4. Discussion

The Northern Hemisphere climate has continued to change in the 21st century, and there have been many studies on responses and changes in distributions of fauna and flora (e.g. Lehikoinen *et al.* 2013; Lehikoinen & Virkkala 2016; Thackeray *et al.* 2016). We found that over the past 25 years winter populations of this group of bird species has increased in Tatarstan. We have also shown that that a major factor associated with such changes of abundance is climate. The significant relationships between winter numbers of birds and temperature in summer and winter has confirmed our thoughts about the existence of a "climatic" concept of regulation of number of birds.

In comparing the population dynamics of birds in our region with data from other parts of Europe, we are fac-

Table 5: Spearman's rank correlations (r_s) between winter bird density in the first and second halves of winter. – *Rangkorrelationen nach Spearman (r_s) zwischen winterlicher Vogeldichte in der ersten und zweiten Winterhälfte.*

Species – *Art*	r_s	p
Great Tit – *Kohlmeise*	**0.695**	**0.0001**
Blue Tit – *Blaumeise*	0.298	0.1480
Willow Tit – *Weidenmeise*	**0.482**	**0.0150**
Marsh Tit – *Sumpfmeise*	**0.600**	**0.0014**
Coal Tit – *Tannenmeise*	**0.662**	**0.0003**
Long-tailed Tit – *Schwanzmeise*	**0.571**	**0.0030**
Nuthatch – *Kleiber*	**0.598**	**0.0016**
Treecreeper – *Waldbaumläufer*	**0.640**	**0.0006**
Goldcrest – *Wintergoldhähnchen*	**0.685**	**0.0002**
Crested Tit – *Haubenmeise*	**0.674**	**0.0002**

Fig. 7: The relationships between abundance of Marsh Tit and Goldcrest in the second half of winter and numbers of days with temperature < -25 °C. Blue solid line represents significant relation between variables based on regression analysis. – *Zusammenhänge zwischen der Abundanz von Sumpfmeise und Wintergoldhähnchen in der zweiten Winterhälfte und der Anzahl der Tage mit Temperaturen < -25 °C. Die blaue Linie stellt das auf Regressionsanalyse beruhende signifikante Verhältnis zwischen den Variablen dar.*

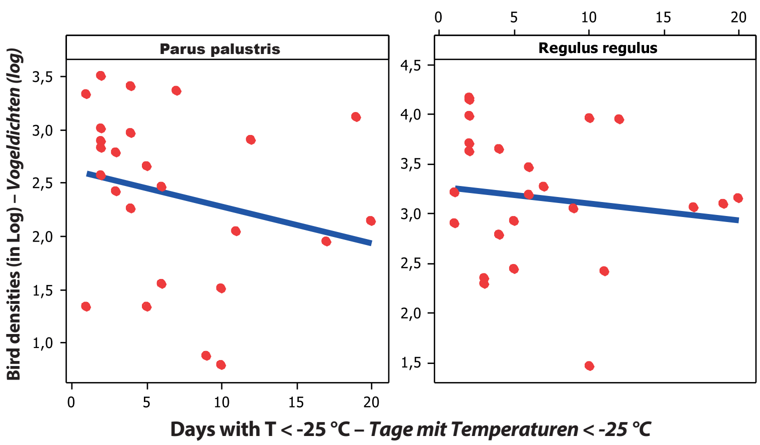

Table 6: Regression coefficients (slope: B ± SE) from linear regressions between bird densities in the second half of winter and winter temperatures in the same year (effects of current temperature). – *Regressionskoeffizienten (Steigung: B ± Standardfehler) der linearen Regressionen zwischen Vogeldichten in der zweiten Winterhälfte und Temperaturen im selben Jahr (Effekte der aktuellen Temperatur).*

Species – *Art*	Winter T – *Wintertemperatur*	
	B ± SE	p
Great Tit – *Kohlmeise*	0.12 ± 0.09	0.170
Blue Tit – *Blaumeise*	**0.16 ± 0.05**	**0.007**
Willow Tit – *Weidenmeise*	0.15 ± 0.09	0.100
Marsh Tit – *Sumpfmeise*	0.09 ± 0.07	0.180
Coal Tit – *Tannenmeise*	-0.04 ± 0.13	0.750
Long-tailed Tit – *Schwanzmeise*	**0.33 ± 0.11**	**0.008**
Nuthatch – *Kleiber*	0.007 ± 0.05	0.900
Treecreeper – *Waldbaumläufer*	0.11 ± 0.07	0.170
Goldcrest – *Wintergoldhähnchen*	**0.19 ± 0.09**	**0.049**
Crested Tit – *Haubenmeise*	0.15 ± 0.10	0.160

ing difficulties as many studies use data on bird numbers from an extremely short time period (e.g. Christmas counts) and collected by a large number of volunteers in very mild winter conditions. We did compare the dynamics of winter bird populations in Tatarstan with those in Sweden and Finland, where severe winters also occur. In Sweden in the middle winter period (Christmas census) the numbers of Marsh Tit, Willow Tit, Crested Tit, Coal Tit, Treecreeper and Goldcrest significantly decreased (Green *et al.* 2016) over the same time period (1991-2015) as considered in our study. In Finland, also in mid winter, Willow Tit, Crested Tit and Goldcrest numbers decreased as well (https://rengastus.helsinki.fi/tuloksia/Talvilintulaskenta), again considering the period 1991-2015. Our results for these species differ markedly with abundance trends in the opposite direction. However, changes in numbers of Blue Tit, Great Tit and Nuthatch (in Sweden) were very similar. This may indicate that species more strongly associated with coniferous forests respond differently to climate change in different parts of the European subcontinent, and that perhaps there has been a significant redistribution in the boreal part of Europe. We therefore recommend a large study involving data from all parts of Europe.

The influence of harsh winter conditions on the survival of birds in winter is well known. Work carried out in parts of Europe where there is a "real winter", has a valuable role in understanding the impact of these changing conditions on the survival of birds. In this context, we call on scientists from regions where the winter is rarely below -5 °C to reconsider their definition of a harsh winter. The likely reason for a higher survival rate of birds in our region in winter and optimal breeding conditions in summer is the fact that the climate in our territory has changed rapidly. In our region, climate change was more rapid than, for example, in Fennoscandinavia. Temperature change of early winter (November-December) in Finland in the last 50 years was not significant (Fraixedas *et al.* 2015), but in our region we experienced a significant increase of 3 °C. In summer in Fennoscandinavia (Lehikoinen *et al.* 2014) temperature increase in the last 50 years was only 1 °C but in our region was more than 2 °C. This is important for the interpretation of bird dynamics in different regions, but especially for sedentary or short-distance migrants. Significant changes in winter conditions, as well as during the breeding season, and a general increase in annual temperatures were associated with a significant increase in the number of birds in winter. In our opinion, it is the combination of these changed climatic parameters that caused increases in bird populations. We consider that the dynamics of bird numbers are primarily determined by climatic factors, through their influence on survival rate of adult birds in winter and of juveniles in summer.

We believe that based on future projections, changes in climate will have a considerable effect on the populations of birds and that in forthcoming years we will better understand how these changes have impacted animal communities.

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5. Zusammenfassung

Askeyev, O., A. Askeyev & I. Askeyev 2017: Dynamik winterlicher Vogelpopulationen im äußersten Osten Europas. Vogelwelt 137: 134–142.

Seit den 1970er Jahren hat sich das Klima in Europa stark verändert. Die größten beobachteten Veränderungen treten dabei während des Winters auf. Signifikante Veränderungen der Winterbedingungen wurden auch in der Mehrheit der Regionen Russlands festgestellt. Trotzdem ist bisher wenig über den Einfluss steigender Wintertemperaturen auf Populationsdynamiken bei Vögeln bekannt. In diesem Kontext analysiert unsere Studie die Daten zur Vorkommensdichte von zehn, im Wesentlichen als Standvögel zu bezeichnenden Vogelarten. Die Datengrundlage unserer Forschung sind Monitoringdaten, die über einen Zeitraum von 25 Jahren (1991-2015) auf Basis von Transektzählungen erfasst wurden. Kohlmeise, Blaumeise, Weidenmeise, Sumpfmeise, Haubenmeise, Kleiber, Waldbaumläufer und Wintergoldhähnchen zeigten eine signifikante Zunahme ihrer Abundanz. Keine der zehn untersuchen Arten zeigte eine Abnahme der Abundanz.

Die am stärksten korrelierenden Faktoren im Hinblick auf das beobachtete Populationswachstum waren Anstiege der Jahrestemperatur, der Wintertemperatur und der Temperatur des der jeweiligen Brutzeit vorangegangenen Winters. Ähnliche Populationsdynamiken wurden für einige der hier untersuchten Arten auch in Finnland und Schweden beobachtet. Gleichzeitig unterscheiden sich die Populationstrends für Weidenmeise, Wintergoldhähnchen und Haubenmeise in der hier vorgestellten Studie deutlich von den Entwicklungen in anderen Regionen Europas. Dies deutet darauf hin, dass klimatische Änderungen innerhalb kurzer Zeit zu Bestandsveränderungen von Vogelpopulationen führen können und das sich die Trendentwicklungen in Osteuropa deutlich von den Entwicklungen im westlichen Teil des Kontinents unterscheiden können. Die Einbeziehung von Monitoringdaten aus einer größeren Stichprobe europäischer Regionen würde helfen die Reaktionen von Vögeln auf den Klimawandel genauer untersuchen zu können.

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The diversity of aquatic birds and breeding of some species in Al-Mallaha, Tripoli

Eman Benyezza, Tahani Shanan, Ali Berbash & Khaled Etayeb

Benyezza, E., T. Shanan, A. Berbash & K. Etayeb 2017: The diversity of aquatic birds and breeding of some species in Al-Mallaha, Tripoli. Vogelwelt 137: 143–148.

The presented study started to monitor the breeding and populations dynamics of waterbirds at Al-Mallaha wetland, Libya, in March 2014. Mallaha is a salt marsh, fed by a canal from the sea all year-round and by rainfall during winter. The area is classified as a site of national importance for Black-winged Stilt, Great Cormorant, Dunlin, Greater Flamingo, Shoveler and Teal. Summing up the peak counts of all 47 species observed during the study period results in a figure of 1966 individuals (not a total value as not accounting for turnover in individuals). A peak in numbers occurred during the last week of April 2014. The study also reported nine important waterbirds species that are mentioned in the Annex II, RAC/SPA. Moreover, this study observed a total of 41 and 32 nests with different clutch sizes for Black-winged Stilt and Little Tern, respectively. Breeding success of both species was significantly affected by predation.

Key words: breeding, population dynamic, waterbirds, Al-Mallaha, Libya

1. Introduction

Libya is characterized by different landscapes leading to a large variety of ecosystems. Accordingly, it has been classified into two eco-regions: a northern region with two parts (the coastal plain and mountainous areas in the north, and the median zone, which is the pre-Sahara region); and a southern region representing the Sahara, with some oases and mountains (Bundy 1976). Most of these areas are frequented by migratory birds in differing numbers, particularly the areas along the Mediterranean coast, where the variety of wetlands and water bodies and the Mediterranean climate produce favourable conditions.

The Libyan coast, with a length of about 1,700 km, includes many areas used as stopovers by numerous species of migratory birds. These areas provide shelter and food. Wetlands are valuable habitats for birds; especially resident and migratory waterfowl (Defos *et al.* 2001). The importance of wetlands is reflected by their relevance for biodiversity in general, the provision of renewable natural resources, as well as endangered species of birds (Sheldon *et al.* 2005).

Libyan wetlands are commonly either shallow salty and open pools which remain dry or semi-dry most of the year, or are connected to the sea. Both types of wetlands are found along the coastal strip. They attract many species of waterbirds, especially in the winter when water levels are high. Here it should be noted that the winter waterbird census, which takes place in most countries of the world during January of each year, began in Libya in January 2005 (Smart *et al.* 2006). In term of studies of birds, Libya is one of the latest states to take an interest in this matter; preliminary studies were carried out by scientific missions or volunteer ornithologists, mainly foreigners, but there was a lack of information on Libyan birds, especially during the past decades (Azafzaf *et al.* 2005, 2006).

In this paper we present studies of one of the important wetlands in the Tripoli area, called Al-Mallaha. The study aimed to classify the site according to the standards of the Ramsar Convention on Wetlands, and also to monitor the waterbirds and study the nesting of some species at the site.

2. Description of study area

Al-Mallaha is situated in the north-east of the city of Tripoli (at 32° 53’ 58 N and 13° 17’ 15 E, Fig. 1). It occupies an area of approximately 3.75 hectares. Al-Mallaha is naturally rich in salt. An extraction plant previously exploited salt in the area, but this plant stopped working a long time ago and only ruined buildings remain (Fig. 2). The southern part of the site is semi-moist with dense vegetation and bounded by the runway of Maitiga air base. There are also stacks of many types of solid waste, metals and the remains of military machinery. In addition to housing and the old buildings, there are military construction and dirt roads around the marsh area.

Fig. 1: Map of study area. – *Karte des Untersuchungsgebiets.*

Although there was no analysis of water quality, the changes in colour and the smell of the water indicate a partial contamination of the area and the soil as a result of leakage of sewage from Maitiga base buildings. The Sabkha (marshy area) is connected to the sea through a channel about 600 meters in length, which supplies water to the Sabkha. Currently it has been blocked due to maintenance and paving of the road located between the sea and the airport of Maitiga.

The Sabkha of Al-Mallaha is divided into a set of rectangles separated by sand embankments, some covered with bushes of tamarisk *Tamarix* and rushes *Scirpus*. During summer these banks are utilized by birds for nesting.

Fig. 2: Old building of salt extraction plant. – *Ehemaliges Betriebsgebäude aus Zeiten der Salzgewinnung.*

3. Materials and methods

This study was conducted from March 2014 to January 2015, omitting the period from August to October when the area was completely dry and the security situation was not appropriate. Visits were twice a week to count the aquatic birds with three visits a week during the nesting period (April to June); 64 survey visits were made in total. Counts were made by walking around the site. An old building overlooking the sites usually acted as starting point. Optolyth, Opticron telescopes and Opticron binoculars (10 x 50) were used. To identify birds, field guides (Heinzel *et al.* 1998, Mullarney *et al.* 1999) were used, together with a digital camera (Canon D700) with a 70-300 mm zoom lens. At the beginning of each nesting period, sand banks between the marshy flats were numbered and the nests were tagged by plastic tags showing the number of nest and corridor. After the laying of the last egg for each nest, a digital vernier caliper was used to measure the length and width of the eggs.

4. Data analysis

To find the egg volume the following equation was used: $V = K_v LB^2$ (Preston 1974, Narushin 2005), where V = volume, K_v = 0.51, L= length and B = breadth (width).

A linear regression model was fitted to find the relationship between egg volume and brood (clutch) size (number of eggs in the nest).

5. Results

5.1 Area classification

The site is one of eleven Libyan wetlands ranking among the top 20 in regional importance for waterbirds, waterbird species richness and overall abundance (EGA-RAC/SPA 2012). The site is classified as Ramsar types J and R (where J means a seasonal saline marsh with an outlet to the sea, which may be dry or only slightly damp for some parts of the year, and R means an inland seasonal or intermittent saline lake, often in a closed basin with no outlet).

Summing up the peak counts of all 47 species observed during the study period results in a figure of 1966 individuals (not a total value as not accounting for turnover in individuals) from 14 families (Table 1), with a peak in numbers during the last week of April 2014 (Fig. 3). This study also reported nine important species of waterbirds that are mentioned as threatened in Annex II prepared by the Regional Activity Center for especially protected areas in the Mediterranean (RAC / SPA) (Table 1).

Table 1: Peak numbers of waterbird species counted during the study period during a single visit. – *Höchste bei einer einzelnen Begehung erfasste Bestände von Wasservogelarten.*

Family – *Familie*	Common name – *Artname*	Peak counts – *Gebietsmaxima*
Phalacrocoracidae	Great Cormorant *Phalacrocorax carbo – Kormoran*	11
Ardeidae	Squacco Heron *Ardeola ralloides – Rallenreiher*	1
	Little Egret *Egretta garzetta – Seidenreiher*	7
	Grey Heron *Ardea cinerea – Graureiher*	7
Threskiornithidae	Glossy Ibis ** *Plegadis falcinellus – Sichler*	1
	Spoonbill *Platalea leucorodia – Löffler*	1
Phoenicopteridae	Greater Flamingo *Phoenicopterus roseus – Rosaflamingo*	93
Anatidae	Shelduck *Tadorna tadorna – Brandgans*	48
	Gadwall ** *Anas strepera – Schnatterente*	5
	Pintail *Anas acuta – Spießente*	9
	Marbled Duck *Marmaronetta angustirostris – Marmelente*	27
	Garganey ** *Anas querquedula – Knäkente*	1
Pandionidae	**Osprey * *Pandion haliaetus – Fischadler***	1
Accipitridae	Marsh Harrier *Circus aeruginosus – Rohrweihe*	1
Recurvirostridae	Avocet *Recurvirostra avosetta – Säbelschnäbler*	5
	Black-winged stilt *Himantopus himantopus – Stelzenläufer*	189
Burhinidae	Stone Curlew *Burhinus oedicnemus – Triel*	1
Charadriidae	Ringed Plover *Charadrius dubius – Flussregenpfeifer*	95
	Kentish Plover * *Charadrius alexandrinus – Seeregenpfeifer*	64
	Grey Plover *Pluvialis squatarola – Kiebitzregenpfeifer*	6
	Golden Plover ** *Pluvialis apricaria – Goldregenpfeifer*	71
Scolopacidae	Sanderling *Calidris alba – Sanderling*	4
	Turnstone *Arenaria interpres – Steinwälzer*	2
	Dunlin *Calidris alpina – Alpenstrandläufer*	197
	Curlew Sandpiper ** *Calidris ferruginea – Sichelstrandläufer*	153
	Little Stint *Calidris minuta – Zwergstrandläufer*	160
	Green Sandpiper *Tringa ochropus – Waldwasserläufer*	3
	Common Sandpiper *Actitis hypoleucos – Flussuferläufer*	3
	Greenshank ** *Tringa nebularia – Grünschenkel*	14
	Redshank *Tringa totanus – Rotschenkel*	74
	Marsh Sandpiper *Tringa stagnatilis – Teichwasserläufer*	1
	Bar-tailed Godwit ** *Limosa lapponica – Pfuhlschnepfe*	6
	Curlew *Numenius arquata – Großer Brachvogel*	43
	Ruff *Philomachus pugnax – Kampfläufer*	43
Stercorariidae	Great Skua ** *Stercorarius skua – Skua*	1
Laridae	Black-headed Gull *Larus ridibundus – Lachmöwe*	48
	Slender-billed Gull * *Larus genei – Dünnschnabelmöwe*	164
	Common Gull *Larus canus – Sturmmöwe*	2
	Mediterranean Gull * *Larus melanocephalus – Schwarzkopfmöwe*	25
	Herring Gull ** *Larus argentatus – Silbermöwe*	80
	Yellow-legged Gull *Larus michahellis – Mittelmeermöwe*	120
	Audouin's Gull * – Larus audouinii – *Korallenmöwe*	9
	Lesser Black-backed Gull *Larus fuscus – Heringsmöwe*	49
Sternidae	**Little Tern * *Sternula albifrons – Zwergseeschwalbe***	51
	Sandwich Tern * *Sterna sandvicensis – Brandseeschwalbe*	37
	Caspian Tern * *Hydroprogne caspia – Raubseeschwalbe*	5
	Lesser Crested Tern * *Sterna bengalensis – Rüppellseeschwalbe*	28

* Important waterbirds species mentioned in Annex II, RAC/SPA (Protocol concerning specially protected areas and biological diversity in the Mediterranean). – *Wichtige Wasservogelarten des Anhang II des Protokolls hinsichtlich besonders geschützter Gebiete und biologischer Diversität der Mittelmeerregion (RAC/SPA).*

** Species were recorded for first time at this site. – *Arten die erstmals für das Untersuchungsgebiet nachgewiesen wurden.*

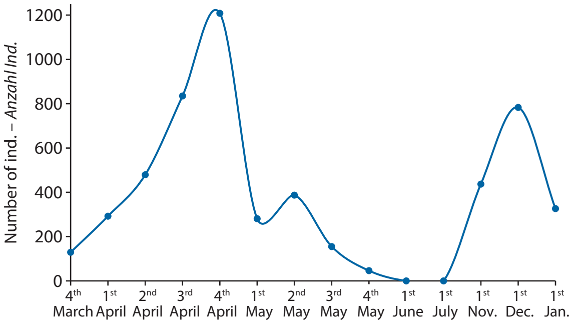

Fig. 3: Combined counts (sum of weekly peak numbers per species) of the 47 waterbird species recorded at Al-Mallaha, by week. – *Kombinierte wöchentliche Zählungen (Summe der Maximalwerte je Art und Woche) der 47 erfassten Wasservogelarten im Untersuchungsgebiet Al-Mallaha.*

5.2 Nesting

During the study period three breeding species were recorded: Black-winged Stilt *Himantopus himantopus*, Little Tern *Sternula albifrons* and Kentish Plover *Charadrius alexandrinus*. The highest abundance of Black-winged Stilt was during the fourth week of April with a total of 189 individuals, whereas nests had been found at the beginning of April; the total number of nests was 41, with differences in clutch size. Nests were found in the aisles with vegetation cover (Fig. 4). Moreover, broken wing behaviour was observed. Nesting of Little Tern started at the end of April; the total number of nests was 32, although the peak number of individuals was 51, during the second week of May. The nests were on the edges of sand banks (Fig. 5). The present study recorded only two nests of Kentish Plover (with one and three eggs). However, this study did not record any hatching of Kentish Plover's eggs. The study found that there was no effect of egg volume on the clutch size in either Black-winged Stilt or Little Tern ($r^2 = 0.014$, df = 1; 32, P = 0.510 and $r^2 = 0.015$, df = 1; 27, P = 0.450) respectively. Moreover, the study found that the hatching rate was 4.4 % for Black-winged Stilt and 20.5 % for Little Tern. However, breeding success of both species was nil (0.0 %).

6. Discussion

The results of this study showed that Al-Mallaha wetland may be classified under two types of wetland, according to the classification for wetland type of the Ramsar Convention; these are J and R, where J means coastal marine wetlands and waters are salty and contact with the sea, while R means inland wetlands, filled with water at certain seasons of the year and which may be dry, salty, brackish or alkaline (Azafzaf *et al.* 2005, EGA-RAC/SPA 2012). The site is very important as a stopover for migratory birds and waterfowl. The study of population dynamics and numbers of individuals and species showed that this site receives large numbers of waterbirds, emphasizing the importance of the site. This is probably because Al-Mallaha is the only natural wetland in Tripoli region.

In total 47 species were recorded during the study, representing the highest number of species recorded since 2005 (Table 2). This diversity reflects the importance of the habitat as an area for foraging, nesting and shelter for many waterbird species. When comparing this study and previous studies on this area, we found that nine species were not previously mentioned (Table 1), this may be due to the length of the study period and the number of visits which gave a greater opportunity to count the number of species in the site.

Seabirds feeding on fish have previously been reported to utilize the area for resting (Etayeb *et al.* 2013). Migratory species stay for a brief period at the site and then resume their journey. The peak in bird numbers was during the last week of April, this perhaps related to the beginning of nesting by species such as Black-winged Stilt. Moreover, the presence of large numbers of some waders such as Dunlin *Calidris alpina*, Curlew Sandpiper *Calidris ferruginea* and Lit-

Fig. 4: Nest of Black-winged Stilt. – *Nest eines Stelzenläufers.*

Fig. 5: Nest of Little Tern. – *Nest einer Zwergseeschwalbe.*

tle Stint *Calidris minuta* coincided with the start of dry season, when the shallower water depth meets the requirements of these species.

The results of this study also showed the presence of nine species mentioned in the RAC/SPA Annex II as threatened species in the Mediterranean (UNEP MAP RAC/SPA 2003). The records of these species emphasize the importance of Al-Mallaha wetland as a good refuge and reflect the need to maintain the natural characteristics of the area, and to recommend its inclusion in the list of Important Bird Areas. Al-Mallaha wetland is considered as a favorable habitat for nesting of some waterbirds (Etayeb *et al.* 2013, 2014), our study recorded nesting of Black winged Stilt, Little Tern and Kentish Plover, as have been recorded previously (Etayeb *et al.* 2013). Another earlier study reported nesting of Marbled Duck *Marmaronetta angustirostris* (Etayeb *et al.* 2014), which demonstrates that the area can provide suitable habitat for nesting of these species. In our recent study we could not confirm breeding of this species.

This study found no relationship between clutch size and egg volume, whereas Blackburn (1991) reported a significant negative relationship between clutch size and egg volumes in Anatidae species. Moreover, Sanchez-Lafuente (2004) found the same result in Purple Swamphen *Porphyrio porphyrio* with a tendency to smaller eggs in larger clutches. However, in Shag *Phalacrocorax aristotelis* and Ring-billed Gull *Larus delawarensis* the size of eggs (egg volume) was affected by the bird's age and the timing of egg laying but not by the clutch size (Ryder 1975).

Hatching was very low in comparison to the number of eggs in both species. This was unexpected and perhaps due to high predation rates by gulls, and the presence of a large number of dogs in the site. These species lay their eggs on the ground, thus they are more susceptible to predation than others (Picman 1988). Many studies have addressed the issue of predation, either of the eggs or chicks, and its negative impact on the overall success rate of the breeding season (Brown & Morris 1994, Thorington & Bowman 2003, Langston *et al.* 2007). Our results found a complete failure of the breeding season of birds in Al-Mallaha.

Table 2: Number of waterbirds species at Al-Mallaha from 2005 to 2014. – *Anzahl der Wasservogelarten im Untersuchungsgebiet Al-Mallaha zwischen 2006 und 2014.*

Study year – *Untersuchungsjahr*	**2005**	**2008**	**2009**	**2011**	**2012**	**2014**
No. of species – *Artenzahl*	24	9	19	34	32	47

Fledging failure in Little Tern is probably due to the disturbance of adults (parents) during the period when chicks are being fed, because after hatching the chicks rely on their parents (fed entirely by the parents). However, the frequent disturbance by humans or by animals such as dogs causes abandonment of the chicks. During our visits we observed footprints and shot cartridges in and around the Sabkha (salt marsh), which confirms the presence of human disturbance. Many studies have reported negative effects of disturbance caused by humans and animals on the abundance and breeding of birds (Bunnell *et al.* 1981, Carney & Sydeman 1999, Finney *et al.* 2005, Burton 2007)

7. Conclusion

The site is classified under Ramsar types J and R (Ramsar Convention wetland classification). The site is important for foraging, roosting and breeding of waterbirds. Moreover, the site is attracting some important (endangered or threatened) bird species. However, this study showed that the highest abundance of birds was during April, which coincides with the breeding of Black-winged Stilt and Little Tern. Egg volumes were not affected by the clutch size in both breeding species. Finally, due to high predation, hatching percentage was very low, and breeding success was 0.0 %.

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8. Zusammenfassung

Benyezza, E., T. Shanan, A. Berbash & K. Etayeb 2017: Wasservogeldiversität und Brutvogelarten des Al-Mallaha Feuchtgebietes, Tripolis. Vogelwelt 137: 143–148.

Die im März 2014 begonnene hier vorgestellte Studie befasst sich mit dem Monitoring der Brut- und Populationsdynamiken von Wasservögeln des Al-Mallaha Feuchtgebiets in Libyen. Mallaha ist eine Salzmarsch die das ganze Jahr über durch einen Kanal mit Meereswasser versorgt wird. Darüber hinaus wird das Feuchtgebiet durch winterliche Regenfälle gespeist. Die Salzmarsch ist als Gebiet von nationaler Bedeutung für Stelzenläufer, Kormoran, Alpenstrandläufer, Rosaflamingo, Löffelente und Krickente klassifiziert. Werden die höchsten artspezifisch erfassten Bestände aller 47 im Untersuchungszeitraum nachgewiesenen Arten aufsummiert, erreicht man einen Wert von 1.966 Individuen (bei diesem Wert handelt es sich nicht um eine absolute Anzahl, da der stetige Zu- und Abgang von Individuen nicht berücksichtigt wird).

Ein Gebietsmaximum in Hinblick auf die erfasste Anzahl von Vögeln wurde in der letzten Woche des Aprils 2016 erreicht. Die Studie konnte neun Wasservogelarten nachweisen die in Anhang II des Protokolls zu besonders geschützten Gebieten und biologischer Diversität der Mittelmeerregion (RAC/SPA) aufgeführt sind. Zudem konnten im Rahmen der Studie insgesamt 41 bzw. 32 Nester des Stelzenläufers und der Zwergseeschwalbe mit unterschiedlichen Gelegegrößen festgestellt werden. Der Bruterfolg beider Arten wurde stark durch Prädation durch Möwen und freilaufende Hunde beeinflusst. Die Schlupfraten im Untersuchungszeitraum waren sehr niedrig und es wurde kein einziger Jungvogel flügge. Das Feuchtgebiet ist als Ramsargebiet mit internationaler Bedeutung für Wasservogelarten ausgewiesen.

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Estimating wintering populations of waterbirds by aerial high-resolution imaging

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Coppack, T., S. McGovern, M. Rehfisch & S. Clough 2017: Estimating wintering populations of waterbirds by aerial high-resolution imaging. Vogelwelt 137: 149–155.

Estimates of avian populations and their dynamics are highly dependent on the accuracy of the applied census technique and the design of spatial coverage. Most estimates of the wintering populations of waterbirds (and seabirds) have so far been derived from surveys using observers positioned on the shore, on ships or in low-flying airplanes. Visual aerial surveys have typically been flown beneath 80 m altitude to allow observers to identify the birds. However, at low altitude, there is a high potential for birds being disturbed and either missed or miscounted. Furthermore, census data collected by visual techniques need to be corrected for distance-related observation bias. Latest developments in digital aerial imaging allow a less invasive census of waterbirds, while solving the problem of distance-dependent detectability. From orthogonal high-resolution digital images, it is possible to map locations of individuals and estimate bird population sizes with a high degree of precision. For example, from high-resolution digital still aerial surveys it was calculated that 14,161 Red-throated Divers *Gavia stellata* were present in the Outer Thames Estuary, which represented the highest number ever reported for a single site in north-western Europe. It is likely that earlier visual surveys had underestimated the numbers of divers present in this Special Protected Area (SPA). Simulated sampling regimes based on gapless digital still imagery indicate that a line-transect sampling design, in which survey effort is confined to widely spaced trajectories, does not account adequately for non-randomly distributed waterbird species, such as seaducks (including the Common Scoter, *Melanitta nigra*). Alternatively, a grid-based, equidistant sampling design may result in higher precision and greater confidence in population estimates at lower levels of coverage. We discuss the relative importance of survey precision and spatial coverage and address the challenges in further improving the efficiency of digital aerial surveys.

Keywords: digital aerial surveys, marine conservation, EIA, monitoring, offshore, seabirds

1. Introduction

The actions taken by humans to mitigate and to adapt to global climate change are currently leading to an increased exploitation of marine resources with presumed – although largely unquantified – effects on marine wildlife. The anticipated growth of offshore wind farm installations, for example, could lead to a significant loss of undisturbed habitat for seabirds and wintering waterbirds (Mendel & Garthe 2010, Dierschke *et al.* 2012, Welcker & Nehls 2016, Dierschke *et al.* 2016). Exact data on the abundance and distribution of waterbirds and seabirds are thus becoming increasingly important to be able to distinguish cumulative impacts of human activities from natural fluctuations (Markones *et al.* 2008, Skov *et al.* 2016).

Seasonal or monthly surveys of waterbirds and seabirds represent snapshots (random samples) of local populations that form part of unknown metapopulations. The robustness of site-specific population estimates and the statistical power of detecting changes in the abundance of seabirds depends largely on the accuracy of the applied survey technique, the design and level of spatial coverage, and on the timing of the surveying effort relative to the phenology and stochasticity of a given species (Markones *et al.* 2008, Maclean *et al.* 2013).

Waterbirds and seabirds have typically been counted by observers positioned on the shore, on the deck of a ship or in low-flying aircraft moving along linear transects, thereby recording the frequency of observed birds and estimating the distance of individuals from the point of observation (Garthe *et al.* 2002, Diederichs *et al.* 2002, Camphuysen *et al.* 2004). These observer-based survey methods often only provide unreliable population estimates, especially for bird species that aggregate in large numbers and that are difficult to count from a single point in time and space. Ships (Schwemmer *et al.* 2011) and low-flying aircraft (Kulemeyer *et al.* 2011) potentially disturb sensitive bird species, introducing further uncertainty in the estimation of displacement effects and small-scale population trends. Furthermore, theoretical models correcting for distance-related observer-bias (Buckland *et al.* 2001) often assume random distribution of individuals. This is evidently not the case in benthivorous seaducks that aggregate in response to the accessibility of their invertebrate food. A biased detection of birds in combination with simplified spatial assumptions and inappropriate correction factors generate inaccurate population estimates and erroneous effect sizes. Here, we report on the evident methodological improvements in estimating populations of waterbirds and seabirds by using aerial high-resolution imaging.

2. Digital aerial surveys

Recent developments in digital aerial imagery allow a less invasive and safer census of waterbirds and seabirds as compared to conventional observer-based approaches, thereby solving major problems with previous survey methods (Buckland *et al.* 2012, Taylor *et al.* 2014, Kemper *et al.* 2015). Survey data resulting from orthogonal digital images do not need to be corrected for distance-related detection bias. Furthermore, digital images create a permanent record and provide the possibility for repeated analyses at raw data level. This is a major advantage over observer-based protocols that cannot be quality-assured once a survey is completed.

The use of aerial photography for bird surveys (for historic examples see Chattin 1952, Grzimek & Grzimek 1960) was for long bound by the physical constraints of celluloid. With the rise of georeferenced digital imaging, and the availability of large digital archives, these limitations do no longer exist. Digital aerial survey techniques have been increasingly used since about 2007 in environmental impact studies for the offshore wind industry (Thaxter & Burton 2009). Both videographic and photographic techniques are deployed (Buckland *et al.* 2012). Videography benefits from a higher frame rate though at the cost of a smaller frame (foot-print) size per camera unit. Therefore, multiple parallel video streams are recorded to achieve sufficient

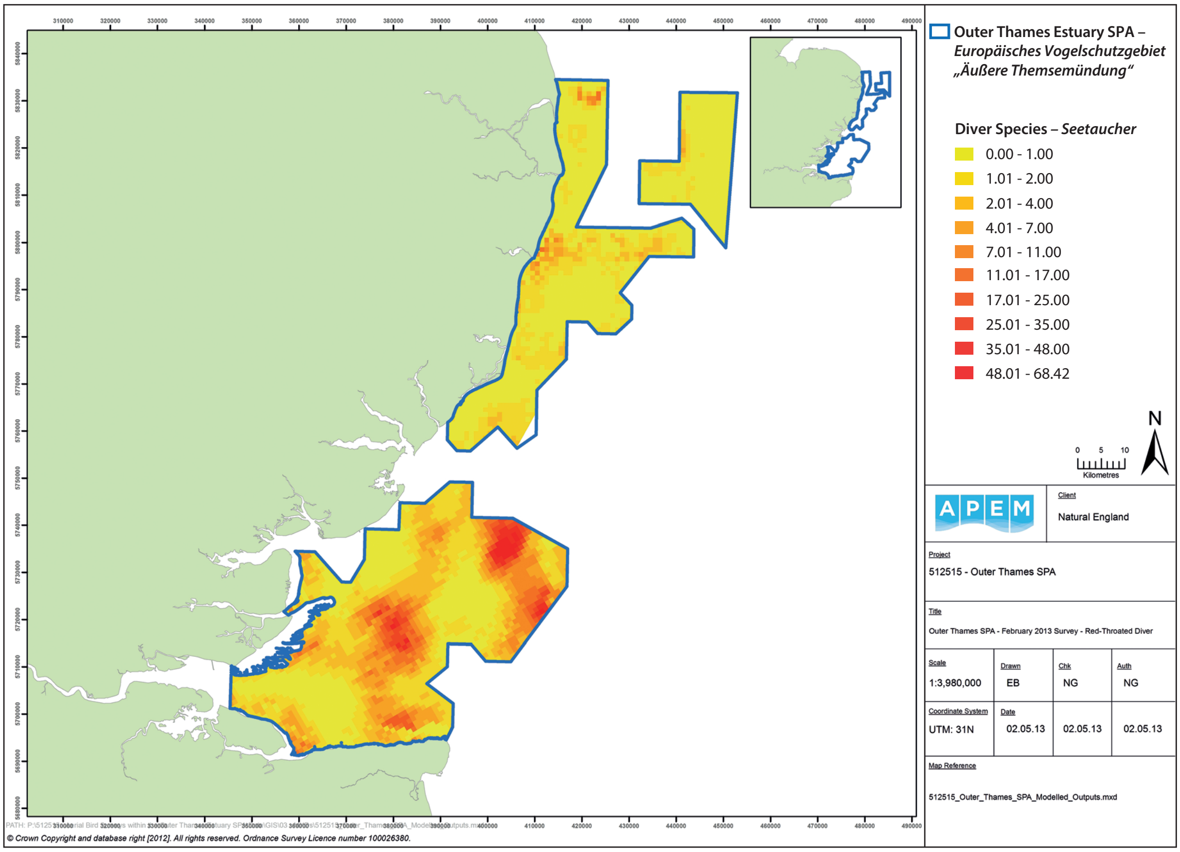

Fig. 1: Modelled distributions of Red-throated Divers in the Outer Thames Estuary SPA during February 2013. Diver densities are predicted on a grid of 1 km resolution across the SPA based on a statistical model fitted to the underlying diver survey data (taken from APEM Ltd 2013: Aerial bird surveys in the Outer Thames Estuary SPA, unpublished report for Natural England). – *Modellierte Verteilung von Sterntauchern in der äußeren Themsemündung vor der Ostküste Englands im Februar 2013. Die Seetaucherdichten wurden basierend auf einem statistischen Modell, das den zugrundeliegenden Erfassungsdaten angepasst wurde, auf Rasterzellen von 1 km Kantenlänge auf die Fläche des Europäischen Vogelschutzgebiets (SPA) hochgerechnet (aus APEM Ltd 2013).*

areal coverage. High-resolution digital photography, on the other hand, compromises frame rate in favour of a larger aspect ratio per camera unit. The use of high-resolution photogrammetric equipment currently enables aerial digital surveys at flight altitudes of over 400 m and with a ground sampling distance (GSD) of 2 cm or less, depending on the specifications of the lens and the distance between aircraft and the avian target.

At higher flight altitudes, flushing of sensitive bird species through the presence of the aircraft is likely to be reduced. Results from simultaneous surveys comparing observer-based methods with the digital aerial approach have generally shown that numbers (or estimated densities) of waterbirds and seabirds are lower when recorded with observer-based methods (Thaxter & Burton 2009, Kulemeyer *et al.* 2011, Weiss *et al.* 2016), suggesting that digital aerial surveys potentially provide more accurate population estimates than conventional observer-based methods.

3. The case of the Red-throated Diver in the Outer Thames Estuary SPA

In January and February 2013, APEM Ltd carried out two aerial surveys over the Outer Thames Estuary SPA (Fig. 1) using aerial digital photography (Leica RCD30, 3 cm GSD, Fig. 2). Continuous digital still images were collected during each survey along 63 transects. With transects spaced 1.8 km apart, a coverage of 15% of the SPA was achieved in each survey (Goodship *et al.* 2015). The number of Red-throated Divers present in the sampled area was extrapolated to the entire SPA using design-based modelling (for methodological details see Goodship *et al.* 2015).

The peak number of 14,161 Red-throated Divers recorded in February 2013 represented 83% of the most recent estimate of the British wintering population (O'Brien *et al.* 2008), and was more than twice the previously designated population of 6,466 in the Outer Thames Estuary SPA (O'Brien *et al.* 2008, Webb *et al.* 2009).

The survey results reported in Goodship *et al.* (2015) represented the largest aggregation of divers ever observed in a single site in north-western Europe. The highest densities were generally recorded in the southern part of the SPA (Fig. 2). While diver numbers recorded in the Outer Thames Estuary SPA may have increased in recent years (despite the construction of large offshore windfarms), it is also possible that divers were previously under-recorded by visual aerial surveys.

4. The relative importance of sampling design and coverage

Linear transect survey designs have been the most widely used method in visual ship-based and aerial surveys (Thaxter & Burton 2009), and calculations of potential displacement effects of human-activities on birds have therefore been based on a limited number of independent observations. Transect surveys, whilst

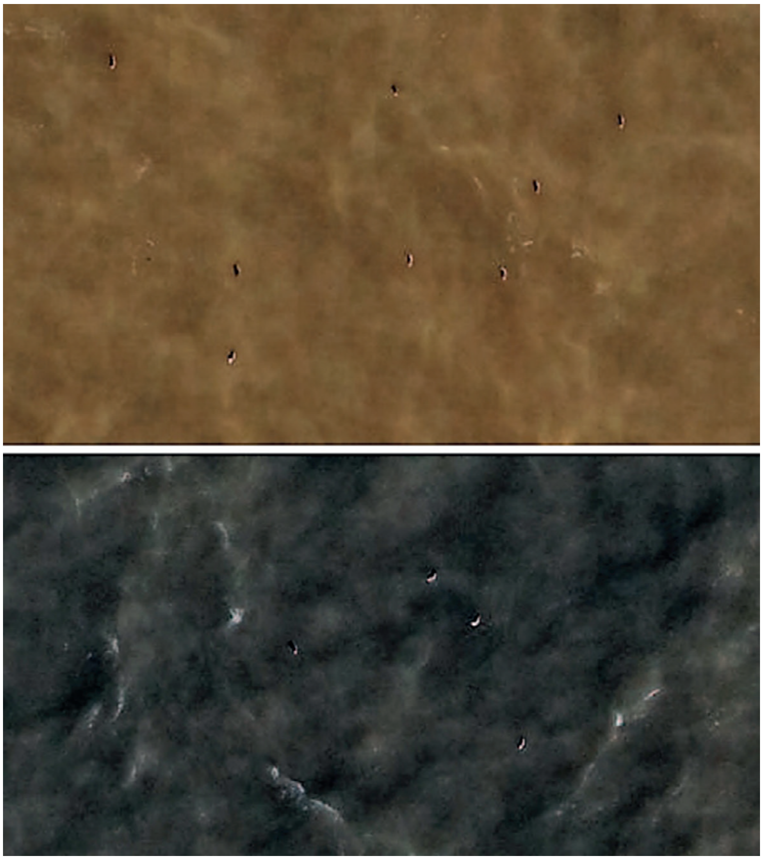

Fig. 2: Digital aerial images (3 cm GSD) from the Outer Thames Estuary SPA in winter 2013, showing 12 Red-throated Divers, taken from Goodship *et al.* (2013). – *Digitale Luftbilder (3 cm Bodenauflösung) mit 12 Sterntauchern, die im Winter 2013 im Europäischen Vogelschutzgebiet (SPA) der äußeren Themsemündung vor der ostenglischen Küste aufgenommen wurden, aus* Goodship et al. *(2013).*

providing high coverage for a lower cost per unit area do not sample the area evenly and therefore may altogether miss areas with important underlying environmental variables that may hold higher or lower densities of a species, thus making the survey estimates unreliable. A grid survey design based on the traditional quadrat ecological surveys, however, samples the area systematically and is less prone to missing areas of possible significance. A more even spatial coverage is especially important in species that tend to aggregate in large flocks (Rexstad & Buckland 2009). If large flocks are present in the wide gaps between transects they may be missed, reducing the reliability of the population estimate. As most transect surveys collect data from relatively few transects, there can be much variation between transects in the numbers of individuals recorded. This reduced sample number will increase the confidence intervals in the population estimate and reduce its precision, making it more difficult to assess changes over time. Due to grid cells normally being separated by a large distance, each individual cell can be considered to be a separate and independent sample (Buckland *et al.* 2012). The independence of the cells can be formally tested for to ensure that there is no pseudo-replication which would invalidate the assumptions of statistical tests. Grid surveys thus normally have a much greater sample number, reducing variation between images and resulting in a greater confidence in the estimate and a high degree of precision.

We have tested these hypotheses based on aerial digital photos captured as part of a research project undertaken off the coast of England (McGovern *et al.*, in prep.). Transects made up of continuous digital stills imagery were flown along 15 transects at 2 km intervals to achieve a survey coverage of approximately 10% of the area, resulting in a total of 1,236 aerial images. To assess the difference in survey methodology, two contrasting species (-groups) present within the data set were chosen for the simulation, i.e. Scoter species (*Melanitta nigra, Melanitta fusca*) that aggregate into flocks in response to their benthic food resources and the Common Gull *Larus canus* as an example of a species that is more evenly distributed. In total 1,738 scoters and 90 common gulls were recorded in the 1,236 images. The number of birds per image by species/species-group, was calculated for individual images for the grid design, and then summarised into transects for the transect design. These data were used as the basis for repeated random sampling with replacement (bootstrapping). Preliminary results of this simulation indicate that a line-transect design, in which survey effort is confined to widely spaced trajectories, does not account adequately for non-randomly distributed species (McGovern *et al.*, *in prep.*). The average percentage coverage required to achieve population estimates that reach a given target precision was approximately twice as high for a transect-based sampling as compared to a grid-based sampling of Scoters (Table 1). However, there was no statistically significant difference between sampling approaches for the more evenly distributed and less abundant Common Gull, suggesting that a transect-based survey design is also suitable for monitoring less abundant, pelagic species and potentially achieves comparable results with less flight effort in a shorter period of time.

Table 1: Average percentage coverage required to achieve a population estimate with a target precision of CV ≤ 0.16, the percentage of simulations that achieved the target precision, and the results of the t-tests for both the grid and transect sampling designs for Scoters and the Common Gull. Precision, based on the Coefficient of Variation (CV), indicates the ratio of the mean to the standard error; the target level of precision was set to CV ≤ 0.16 that corresponds to a level of precision at which a doubling or halving of the population is detectable. Measures of precision were calculated using a Poisson estimator (pCV), suitable for a Poisson over dispersed distribution (adapted from McGovern *et al.*, in prep.). – *Die durchschnittliche prozentuale Flächenabdeckung, die erforderlich ist, um eine Populationsschätzung mit einem Variationskoeffizienten (CV) von ≤ 0,16 zu erreichen, der Prozentsatz der Simulationen, die diese Zielgenauigkeit erreichten, sowie die Statistik des t-Tests für das Grid- und Linientransekt-Design für Trauerente/Samtente (*Melanitta *spec.) und Sturmmöwe. Der Variationskoeffizient gibt das Verhältnis des Mittelwertes zum Standardfehler an; die Zielgenauigkeit lag bei CV ≤ 0,16, was einer Genauigkeit entspricht, bei der eine Verdopplung oder Halbierung der Population nachweisbar ist. Präzisionsmessungen wurden unter Verwendung eines Poisson-Schätzers (pCV), der für eine über-dispergierte Poisson-Verteilung geeignet ist (nach McGovern* et al.*, in Vorb.).*

Species – ***Arten***	**Sampling design** – ***Stichproben-design***	**Average percentage coverage (± 95% confidence interval) required to reach a precision of ≤ 0.16** – ***durchschnittliche prozentuale Abdeckung (± 95 % Konfidenzintervall) notwendig um eine Präzision ≤ 0,16 zu erreichen***	**Population estimate (± 95 % confidence interval)** – ***Populationsschätzung (± 95 % Konfidenzintervall)***	**Percentage of simulations that achieved a precision of 0.16** – ***Anteil der Simulationen, die eine Präzision von 0,16 erreichten***	**t**	**p**
Scoter *Melanitta spec.*	Grid	0.90 ± 0.13	15,982 ± 3,410	100	-7.2954	<0.05
	Transect	2.16 ± 0.31	17,733 ± 5,808	100		
Common Gull *Larus canus*	Grid	5.18 ± 0.37	829 ± 68	100	-0.2476	0.8047
	Transect	5.25 ± 0.42	836 ± 70	97.98		

This finding is in general agreement with simulations carried out on the basis of gapless digital still imagery from the western Baltic Sea (Bay of Wismar, Germany) that captured the complete distributions of individual Common Eider *Somateria mollissima*, Long-tailed Ducks *Clangula hyemalis* and Common Scoters (Steffen 2014). The results indicate that population estimates of aggregated seaducks resulting from transect sampling are very susceptible to spatial phase shifts. To achieve population estimates that deviate less than 50% from the true number of individuals in the area, a coverage of over 25% was necessary with transect sampling, while a grid-based design required 10 to 15% coverage to achieve a comparable degree of precision (Grenzdörffer *et al.* 2016).

5. Conclusions and future developments

The use of high-resolution aerial imagery to map seabirds and waterbirds shows several advantages over observer-based methods. Site-specific frequencies of individuals can be determined without correcting for distance-related observation bias (Buckland *et al.* 2001), and the resulting population estimates remain verifiable at raw-data level. The method can also be applied to complement land-based waterbird counts, e.g. in protected areas, and to advance national or international monitoring schemes.

From a statistical and biological point of view, greater percentage coverage is required by a linear-transect than by a grid-based survey design to achieve an equivalent level of data quality and confidence in population estimates. Digital grid-based aerial surveys reduce the risk of over-recording (multiple counts of the same individuals). A further strength of the grid-based method is that it samples the survey area proportionally, which is an advantage if the sampled area has highly clumped distributions of birds or includes spatially limited structures or zones (sandbanks, wind turbine arrays, shipping lanes), which can be over- or under-represented in widely spaced transect surveys.

There are currently several methodological challenges both in image analysis and image acquisition that need to be overcome in the future. From a logistical and economic perspective, it is reasonable attempting to capture the full range of bird species with the same sensor technique, under the same sampling regime, and within the shortest possible time window. However, while white gull species are clearly visible against the dark background of the sea surface (in areas that are free of glare, glint, and spray), scoters or auks can merge more with their environment and can be harder to detect. These varying signal-to-noise relationships between groups of species require a high quantization of the imaging channels and filters, imposing equivalent requirements on the image processing software (Kemper *et al.* 2016).

So far, birds have been usually targeted visually (subjectively) in aerial digital images. With the increasing regular use of aerial digital methods, image pre-processing (object recognition) should be automated to accelerate and standardise the entire workflow (cf., Groom *et al.* 2013, Mader & Grenzdörffer 2016, Chabot & Francis 2016).

There is also a need to further optimise digital aerial survey efficiency, i.e. to lower survey time and costs per unit area. A higher survey efficiency, however, should not come at the cost of image quality nor geospatial precision. Image quality strongly depends on sea surface conditions related to wind and sunlight and ultimately determines how well species can be (automatically) detected and identified, while spatial precision within georeferenced imagery is a prerequisite for accurately measuring morphometric features that are important for distinguishing species.

In conclusion, digital aerial surveys have a high potential for delivering robust and auditable data on the abundance and distribution of waterbirds and seabirds (Buckland *et al.* 2012). However, there is currently no common standard that defines the technical and methodological requirements for routinely carrying out digital aerial surveys – neither nationally, nor internationally – though research effort is underway. A sound conceptual framework based on clearly defined photogrammetric parameters is urgently needed to allow different sampling approaches, camera sensors and quality features to be objectively assessed and standardized. Rigorous empirical inter-calibration at sensor level (from a single platform using identical targets) and randomised double-blind crossover trials at the level of image analysis and species identification will be essential for establishing universal digital survey standards that allow an objective evaluation of existing observer-based survey data.

6. Zusammenfassung

Coppack, T., S. McGovern, M. Rehfisch & S. Clough 2017: Populationsschätzung von Wasservögeln durch hochauflösende Luftbildaufnahmen. Vogelwelt 137: 149–155.

Die Erfassung von Vogelbeständen und ihrer Dynamik hängt in hohem Maße von der Genauigkeit der angewandten Zähltechnik und von der Form der räumlichen Abdeckung ab. Bislang basieren die meisten Bestandsschätzungen von überwinternden Wasservögeln (und Seevögeln) auf Sichtbeobachtungen, die vom Ufer, von Schiffen oder von niedrig fliegenden Flugzeugen aus durchgeführt wurden. Flugzeuggestützte Erfassungen fanden dabei üblicherweise in Flughöhen unter 80 m statt, um den Beobachtern eine Artansprache zu ermöglichen. Allerdings besteht in dieser geringen Flughöhe ein erhöhtes Potential, dass Vögel gestört, übersehen oder falsch gezählt werden. Darüber hinaus müssen visuell erhobene Zähldaten um den distanzabhängigen Beobachtungsfehler korrigiert werden. Neueste Entwicklungen in der digitalen Luftbildtechnik ermöglichen eine weniger invasive Erfassung von Wasservögeln, während das Problem der distanzabhängigen Erfassbarkeit gelöst wird. Auf der Grundlage von orthogonalen, hoch aufgelösten digitalen Luftbildern ist es möglich, die Positionen von Individuen zu kartieren und Vogelbestände mit hoher Genauigkeit zu schätzen. Beispielsweise wurden in der äußeren Themsemündung vor der Küste Großbritanniens auf der Grundlage digitaler Luftbilder 14.161 Sterntaucher berechnet, was die höchste jemals für einen Standort in Nordwesteuropa gemeldete Zahl darstellte. Es ist wahrscheinlich, dass die Seetaucherzahlen in diesem Europäischen Vogelschutzgebiet (SPA) durch frühere Sichtbeobachtungen unterschätzt wurden. Simulierte Stichproben-Designs auf der Grundlage lückenloser, digitaler Luftbilder deuten darauf hin, dass ein Linientransekt-Design, bei dem der Untersuchungsaufwand auf weit getrennten Fluglinien beschränkt ist, Pulk-bildende Wasservogelarten, wie Meeresenten (einschließlich der Trauerente), nur unzureichend berücksichtigt. Im Gegensatz dazu können mit einem Grid-Design (äquidistante Erfassung an den Knotenpunkten eines gleichmäßigen Rasters) bei niedrigerer Flächenabdeckung präzisere Populationsschätzungen mit größerer Konfidenz erzielt werden. Wir diskutieren die relative Bedeutung der Erfassungsgenauigkeit und räumlichen Abdeckung und benennen die Herausforderungen bei der weiteren Effizienzsteigerung der digitalen Luftbildverfahren.

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Numbers and distribution of wintering waterbirds in the Krasnodar Province, southwestern Russia

Alexander Solokha & Yury Lokhman

Solokha, A. & Y. Lokhman 2017: Numbers and distribution of wintering waterbirds in the Krasnodar Province, southwestern Russia. Vogelwelt 137: 156–161.

With extensive Sea of Azov and Black Sea coasts and inland waterbodies, the Krasnodar Province in SW Russia provides important winter quarters for waterbirds, especially in mild winters. The International Waterbird Census (IWC) was established in the region in 2003 and has been conducted annually since then except for 2007–2009. The coverage varied, depending mostly on the respective wetlands condition (frozen or not). Altogether, 37 sites were counted at least once between 2003 and 2016 with highest coverage (27 sites) in 2004. The total numbers of waterbirds varied from 145,614 in 2003 to 1,112,213 in 2013. Among individual sites, the highest number of waterbirds (353,982) was recorded in Taman Bay in 2013. Altogether, 74 species of waterbirds were identified. Most numerous species were Mallard (the highest total was 396,920 in 2013), Black-headed Gull (243,615 in 2013), Coot (147,390 in 2011), Tufted Duck (137,839 in 2014) and Pochard (106,069 in 2013). Mute and Whooper Swans, Mallard, Black-headed Gull, Tufted Duck and Pochard showed a strong or moderate increase over the period 2003–2016. Four globally threatened waterbird species were found: Dalmatian Pelican, Lesser White-fronted Goose, Red-breasted Goose and White-headed Duck. Along with mild weather, low disturbance in January is a critical factor for waterbirds to stay in the Krasnodar Province. However, infrastructure development and the construction of houses at the sea shores cause a degradation of some important wetland habitats.

Key words: waterbirds, wetlands, Krasnodar Province, IWC, counts, population trends.

1. Introduction

Most Russian wetlands normally freeze by January and therefore are not suitable for wintering waterbirds. However, extensive Sea of Azov and Black Sea coasts and inland waterbodies of the Krasnodar Province often remain free of ice, at least partially, and serve as important winter quarters for waterbirds. Starting from 2003, mid-winter waterbird counts under the International Waterbird Census (IWC) are regularly conducted in the region (Solokha 2006), being included since 2012 in the national and local monitoring schemes. The information obtained from such monitoring has considerable value for hunting management and waterbird conservation in Russia. Besides, the count data are integrated into the central IWC database managed by Wetlands International and therefore contribute to estimating the sizes and trends of waterbird populations across the flyways.

The article presents the results of the IWC surveys performed in the Krasnodar Province from 2003 until 2016, except for missing seasons of 2007–2009.

2. Methods

The IWC is a site-based counting scheme for monitoring waterbird numbers. It is a so-called look-see survey whereby observers visit a site and make a count of every waterbird species present (Bibby *et al.* 2000, Delany 2005). We used ground and boat surveys to count waterbirds during several days in January. The large extension of wetlands as well as the lack of experts and trained volunteers did not allow us to carry out simultaneous counts at all suitable sites in the Krasnodar Province. However, we tried to do this in as short a time as possible, particularly in the last years, and performed most counts between 10th and 25th January. We used binoculars and spotting scopes with 20–60 magnitudes for observations. Waterbirds were counted, each species separately, one by one, by tens, and, in case of large congregations, also by hundreds of individuals.

Following the methodology of the IWC in the Western Palearctic and Southwest Asia (Delany *et al.* 1999, Gilissen *et al.* 2002) we recorded all "traditional" waterbird species, related to such groups as divers, grebes, pelicans, cormorants, egrets, herons, bitterns, geese, swans, ducks, cranes, rails, gallinules, coot, waders, gulls and terns. The sequence of species follows the Waterbird Population Estimates – Fifth Edition (Wetlands International 2012).

The coverage of IWC in Krasnodar Province varied, depending mostly on the condition of wetlands (frozen or not), but also from available time and funds. Altogether, 37 sites were counted at least once with highest coverage (27 sites) in 2004. No counts were conducted in January 2007–2009 due to lack of funds and organizational problems (Table 1).

The standard customized software Excel and Access were used for data collation and treatment, and a free program DIVA-GIS for mapping and spatial presentation. We calculated trends for the species that regularly winter in significant

Table 1: Summary results from mid-winter waterbird counts in Krasnodar Province since 2003. – *Zusammenfassung der Ergebnisse der Mittwinter-Wasservogelzählungen in der Region Krasnodar seit 2003.*

Date – *Datum*	Number of covered sites – *Anzahl Zählgebiete*	Number of waterbirds – *Anzahl Wasservögel*	Number of species – *Anzahl Arten*	Notes – *Bemerkungen*
2003: 18.–28.01.	20	145,614	42	
2004: 21.01.–04.02.	27	258,239	50	
2005: 13.01.–05.02.	15	206,303	44	
2006: 03.–21.01.	19	202,332	47	
2007–2009	no counts – *keine Zählung*	-	-	
2010: 16.–29.01.	8	156,905	34	Cold winter. Poor coverage due to lack of funds – *Kalter Winter. Geringe Abdeckung wegen fehlender Finanzmittel*
2011:15.–31.01	12	505,599	41	Poor coverage due to lack of funds – *Geringe Abdeckung wegen fehlender Finanzmittel*
2012: 20.–25.01	5	175,547	28	Poor coverage due to late counts. Cold winter – *Geringe Abdeckung wegen später Zählungen. Kalter Winter.*
2013: 14.–28.01	18	1,112,213	43	
2014: 12.–23.01	14	867,059	46	
2015: 14.–24.01	15	794,033	42	
2016: 13.–24.01	20	661,077	44	

numbers in the Krasnodar Province with the software TRIM 3.53 (Pannekoek & van Strien 2005).These species were Mute Swan *Cygnus olor*, Whooper Swan *C. cygnus*, Teal *Anas crecca*, Mallard *A. platyrhynchos*, Tufted Duck *Aythya fuligula*, Common Pochard *A. ferina*, Coot *Fulica atra*, Common Gull *Larus canus* and Black-headed Gull *L. ridibundus*.

3. Weather conditions

Weather conditions varied from winter to winter. Fig. 1 shows fluctuations of mean January temperatures from 2003 to 2016 in Krasnodar city. Overall mean January temperature in Krasnodar was 0.5 °C during this period, varying between -6.6 °C and 5.1 °C.

Fig. 2 illustrates the change in daily average temperatures during the last five IWC seasons. Steady decline in temperature below 0 °C results in freezing of wetlands. As a consequence most of the waterbirds leave the area, which was clearly seen in the last decade of January 2012. A rather opposite situation was in 2013, when after a cold December a steady increase in temperature in mid-January caused ice melting at inland waterbodies and shallow-water areas along the coasts. Subsequent warm weather led to huge numbers of waterbirds staying along the sea shores and at reservoirs until the end of winter 2013. January 2015 and 2016 were rather cold in the beginning, resulting in freezing of wetlands in the northern part of Krasnodar Province. But temperature increases in the middle of the month caused partial melting of ice cover at these wetlands by the third decade of January.

4. Results

The total counts varied from 145,614 individuals (in 2003) to 1,112,213 individuals (in 2013), while coverage ranged from five sites in 2012 to 27 sites in 2004. Out of nine sites with mean counts above 20,000 waterbirds, four sites, namely Varnava Reservoir, Taman Bay, Kryu-

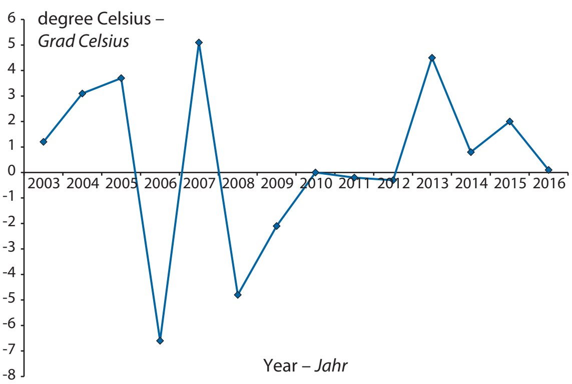

Fig. 1: Average temperatures for January 2003–2016 in Krasnodar city. Data: krasnodarmeteo.ru/archive.php. – *Durchschnittstemperauren im Januar 2003–2016 in Krasnodar.*

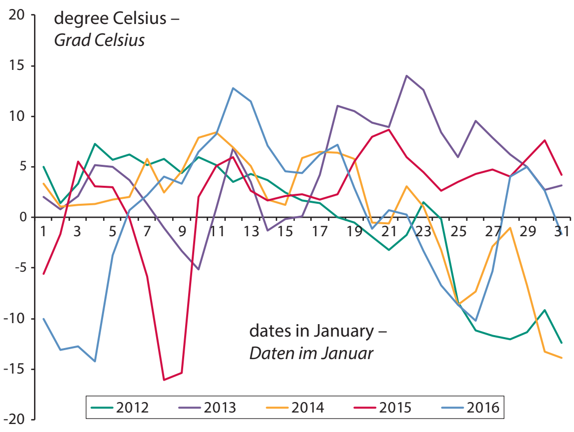

Fig. 2: Daily mean temperature in Krasnodar city for January 2012–2016. Data: krasnodarmeteo.ru/archive.php. – *Tagesmitteltemperatur in Krasnodar im Januar 2012–2016.*

kovo Reservoir and Kiziltash limans, were particularly important and supporting, on average, 100,328, 87,575, 81,453 and 77,470 waterbirds respectively (Fig. 3). The highest number of waterbirds (353,982) was recorded in Taman Bay in 2013.

Altogether, 74 species of waterbirds were identified during 2003–2016 in the Krasnodar Province. The lowest number of species (28) was found in 2012, and the highest number (50) in 2004. Most numerous were Mallard (highest total count was 396,920 in 2013), Black-headed Gull (243,615 in 2013), Coot (147,390 in 2011), Tufted Duck (137,839 in 2014) and Pochard (106,069 in 2013). The characteristics of particular groups are listed below.

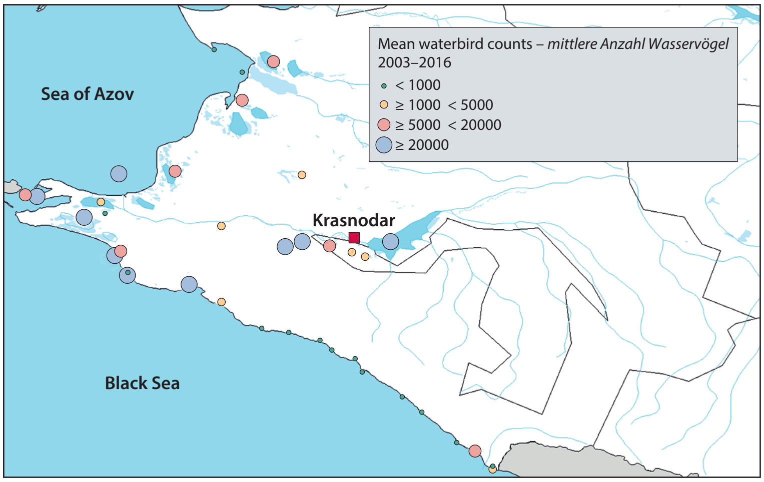

Fig. 3: IWC sites in Krasnodar Province in 2003–2016. Dots indicate mean numbers of waterbirds counted. – *Zählgebiete der Internationalen Wasservogelzählung in der Region Krasnodar von 2003–2016. Die Punkte zeigen die mittlere Anzahl erfasster Wasservögel.*

Divers and grebes

Over the whole period we counted two species of divers and four species of grebes. While Red-throated Diver *Gavia stellata* was found only once (one flock of 47 birds at Varnava Reservoir in 2014), the Black-throated Diver *G. arctica* occurred during eight winter seasons along the Black Sea shores with totals varying from one in 2011 to 2,443 individuals in 2013. In the last case divers concentrated in the Bolshoi Utrish Cove.

Among grebes the Great Crested Grebe *Podiceps cristatus* was most widespread and numerous with totals varying from four birds in 2012 to 36,698 birds in 2015. The majority of them was found along the Black Sea coast in the Anapa Bay and Bolshoi Utrish Cove.

Pelicans and cormorants

Dalmatian Pelican *Pelicanus onocrotalus* was found every winter with total counts from three in 2010 to 111 in 2015. Over the last years pelicans occurred mostly in Novorossisk Bay (the Black Sea) and Temryuk Bay (Sea of Azov).

Two species of cormorants were counted in Krasnodar Province in mid-winter seasons of 2003–2016. Pygmy Cormorant *Phalacrocorax pygmeus* was relatively scarce and found not every winter, with highest count of 575 birds in 2004. Great Cormorant *P. carbo* was numerous and widespread with total counts varying from 2,682 (2013) to 29,628 birds (2014).

Egrets, herons and bitterns

Both Grey Heron *Ardea cinerea* and Great White Egret *Casmerodius albus* were counted every winter. The first species was recorded in numbers from 40 (2006) to 839 (2011), mostly at the Varnava Reservoir and Taman Bay. Great White Egret numbers varied from eight (2010) to 1,919 (2011) birds, and highest numbers were counted around Taman Bay and Kiziltash limans. Single individuals of Little Egret *E. garzetta* and Bittern *Botaurus stellaris* occurred just in some winters, up to seven and eight birds per year, respectively.

Swans

We counted three species of swans in the period 2003–2016. They occupied in total 21 sites, of which the Taman Bay was the most important (highest swan number was 4,779 birds in 2016). Mute Swan was found every winter season, and, in total, it occupied 20 sites varying from three sites in 2010 to twelve sites in 2004, 2006, 2015 and 2016. The total counts differed from 481 in 2010 to 6,994 individuals in 2015, with means of 2,875 ± 624 birds per year. Numbers showed a moderate increase over the whole period ($p < 0.01$; slope model 1.0794 and std. err. 0.0266) (Fig. 4).

Whooper Swan was recorded every winter season, and in total it occurred at 14 sites, varying from two sites in 2005 and 2010 to ten sites in 2016. The total counts differed from 296 in 2012 to 2,560 birds in 2014 (mean 962 ± 225 birds per year). The overall trend showed a moderate increase ($p < 0.01$; slope model 1.0749 and std. err. 0.0247, Fig. 4).

Bewick's Swan *Cygnus bewickii* was firstly found in the region in January-February 2008, when two to five birds were seen in Kerch Strait and neighboring part of Taman Bay (MNATSEKANOV 2008). We recorded this species every January since 2013, and until 2016 its number varied from two (in 2015) to 139 (in 2013). It occurred at three sites, namely Varnava Reservoir (the highest count was 101 birds in 2013), Taman Bay (the highest count was 57 birds in 2014) and Krasnodar Reservoir (only in 2013,18 birds).

Geese

Four species of geese were found in the seasons of 2003–2016, namely White-fronted Goose *Anser albifrons*, Lesser White-fronted Goose *A. erythropus*, Greylag

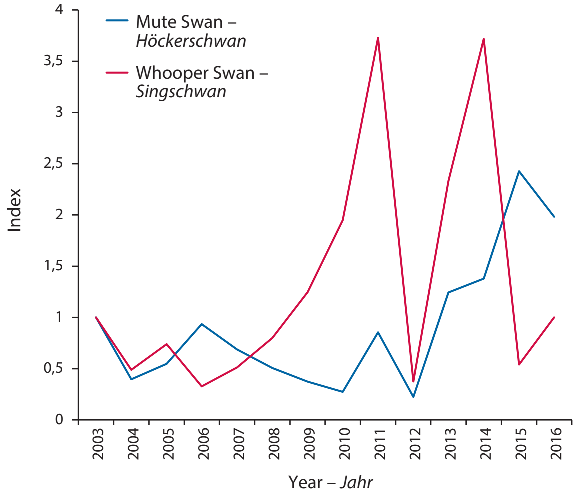

Fig. 4: Trends of Mute and Whooper Swan wintering numbers in the Krasnodar Province 2003–2016. – *Indexentwicklung überwinternder Höcker- und Singschwäne in der Region Krasnodar 2003–2016.*

Goose *A. anser* and Red-breasted Goose *Branta ruficollis*. White-fronted and Greylag Geese have been common and counted every winter season. Their totals strongly fluctuated between years being affected by weather conditions and coverage. Totals changed from two (2003, 2010) to 4,869 (2013) individuals, and from 133 (2010) to 10,427 (2013) individuals, respectively. Varnava Reservoir was the most important wintering site for these species (e. g. in 2013 it hosted 4,473 White-fronted and 7,020 Greylag Geese). Lesser White-fronted Goose appeared just once over the whole count period: two birds were recorded in the vicinity of Taman Bay in 2013. Red-breasted Goose was counted in 2006 (13 birds at Kiziltash limans and two birds at Krasnodar Reservoir) and in 2016 (two birds in Imeretinsky Lowland; Lev Shagarov, pers. comm.)

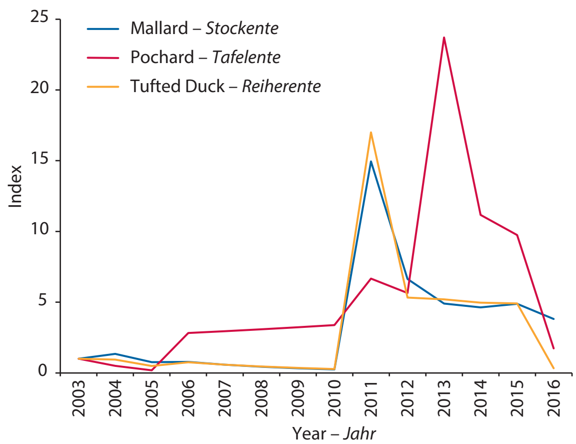

Fig. 5: Trends of the wintering numbers of Mallard, Pochard and Tufted Duck in the Krasnodar Province 2003–2016. – *Indexentwicklung überwinternder Stock-, Tafel- und Reiherenten in der Region Krasnodar 2003–2016.*

Ducks and Coot

Over the whole period we counted 19 species of ducks, including two species of shelducks, seven species of dabbling ducks and ten species of diving ducks (*Netta rufina, Aythya sp. Mergus sp.* and others). Teal, Mallard, Pochard and Tufted Duck were the most numerous and widespread species and occurred every year. We calculated trends for these species, and also for Coot.

Teal held itself over the whole period at 20 sites, varying between one site in 2010 and nine sites in 2006. The total counts differed from 249 birds in 2010 to 56,250 birds in 2011, with a mean of 7,784 ± 4,919 birds per year. Teal showed poorly known (uncertain) trend skewing toward increase (slope model 1.3615 and std. err. 0.1986).

Mallard occupied in total 26 sites, varying from five in 2012 to 18 sites in 2004. The total counts fluctuated from 9,567 birds in 2010 to 396,920 birds in 2013, with a mean of 184,465 ± 47,337 birds per year. The species trend was classified as "strong increase" ($p < 0.01$; slope model 1.2007 and std. err. 0.0322) (Fig. 5).

Pochard occurred at 22 sites, varying from two in 2010 to eleven sites in 2013 and 2016. The total counts differed from 867 birds in 2005 to 106,069 birds in 2013 (mean 28,177 ± 9,511 birds per year). The species showed strong increase in number ($p < 0.05$; slope model 1.2382 and std. err. 0.0890) (Fig. 5).

Tufted Duck occupied 21 sites, varying from two sites in 2010 to eleven sites in 2003 and 2015. The total counts differed from 9,327 birds in 2011 to 137,839 birds in 2014, in the mean 45,564 ± 13,089 birds per year. The species showed a strong increase ($p < 0.05$; slope model 1.1406 and std. err. 0.0379) (Fig. 5).

Coot was also found every year and at many sites in Krasnodar province. It occupied 23 sites, varying from four sites in 2012 to 15 sites in 2004. The total counts differed from 5,397 birds in 2016 to 147,390 birds in 2011, in the mean 35,240 ± 12,585 birds per year. The trend was classified as "uncertain" but skewed towards decline (slope model 0.9308 and std. err. 0.0374) (Fig. 6).

Waders

In general, waders were uncommon wintering birds in Krasnodar Province. Among 19 recorded species, Curlew *Numenius arquata* was the most numerous and occurred every year, primarily at Kiziltash limans (from four to 175 individuals in different years). An interesting finding was a Purple Sandpiper *Calidris maritima* in Novorossiisk Bay in 2016, the first documented record of this species in the region (Lokhman & Solokha 2016).

Gulls and terns

Nine species of gulls and three species of terns were recorded in January 2013–2016. Of them Common Gull, Caspian Gull *L. cachinnans* and Black-headed Gull were the most numerous and widespread species that occurred every year. We calculated population trends for two species and give details below.

Common Gull occurred at 29 sites, between two in 2012 and 24 sites in 2004. The total counts differed from 201 birds in 2012 to 27,223 birds in 2013 (mean 7,566 ± 2,608 birds per year). Overall trend was "uncertain" but skewed towards increase (slope model 1.1225 and std. err. 0.0753).

Black-headed Gull was found at 26 sites, varying from two sites in 2010 and 2011 to 14 sites in 2004 and 2006. The totals heavily fluctuated from 88 birds (in 2010) to 243,615 birds (in 2013) which could be the consequence of differences in count coverage. Over the last years the largest concentrations were found along the Black Sea shore between Anapa Bay and Novorossiisk Bay. Mean count during 2003–2016 was 64,127 ± 24,687 birds. An overall "uncertain" trend was skewed towards increase (slope model 1.7921 and std. err. 0.05906).

Terns were rare in January. Sandwich Tern *Sterna sandvicensis* was the only species to occur almost every winter, primarily in the Novorossiisk Bay, with totals of up to 32 individuals.

Globally threatened waterbirds

Four IUCN Red List (BirdLife International 2016) and Russian Red Data Book (2001) waterbird species were counted during the counts 2003–2016, namely Dalmatian Pelican, Lesser White-fronted Goose, Red-breasted Goose, and also White-headed Duck *Oxyura leucocephala*. The latter species was found in 2013 (five in Kerch Strait and ten individuals in Anapa wetlands) and in 2014 (two birds in Taman Bay).

5. Discussion

Count data varied from year to year depending primarily on conditions of waterbodies (frozen or not) and also on available funds for field trips. During the last five years the lowest number of waterbirds was counted in January 2012 (175,545 birds) and this can be explained by the fact that the counts were relatively late (after 20th January) and affected by a sharp drop in temperature. The highest total (1,112,213 birds) was counted in the mild January of 2013. In January 2016, fog hampered counts in Taman Bay and is likely to have caused an underestimation of swans.

Wintering numbers of Mute and Whooper Swans, Mallard, Pochard and Tufted Duck demonstrated strong or moderate increases from 2003 to 2016. Also numbers of Teal, Common and Black-headed Gulls were increasing to some extent, but with uncertain trends. On the other hand, counts indicated a slight decrease in wintering numbers of Coot. Our results, however, do not correspond to the overall declining trends (between 2002–2012) for Black Sea and Mediterranean (wintering) populations of Pochard and Tufted Duck (Nagy *et al.* 2014). The reason for the difference might be that data from Krasnodar sites, with high counts of both species in 2013, 2014 and 2015, have not been included in the overall trend calculation. For several species, significant proportions of the Black Sea and Mediterranean flyway populations were counted in Krasnodar Province. Nagy *et al.* (2015) estimated the numbers of the relevant flyway populations of Mute Swan at 45,000 individuals, Whooper Swan at 14,000 individuals, Mallard at 1,500,000 individuals, Pochard at 570,000–630,000 individuals and Tufted Duck at 400,000–500,000 individuals. Our results suggest that, at least in some years, Krasnodar Province hosts about 16 % of Mute Swan, 18 % of Whooper Swan, 25 % of Mallard, 16 % of Pochard and 30 % of Tufted Duck flyway populations.

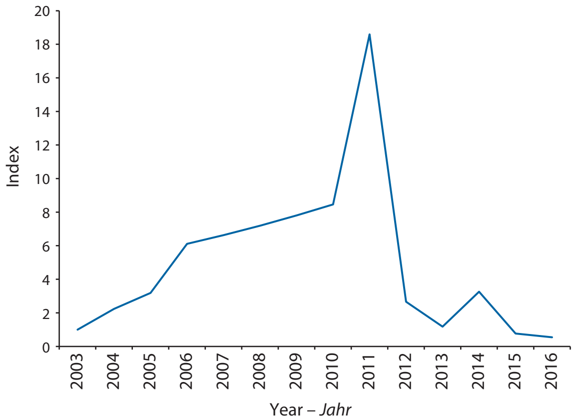

Fig. 6: Trend of the Coot wintering numbers in the Krasnodar Province 2003–2016. – *Indexentwicklung überwinternder Blässhühner in der Region Krasnodar 2003–2016.*

In recent years we counted large numbers of non-identified diving ducks in the Taman Bay, e. g. 53,000 birds in 2013, 23,000 birds in 2015, and 45,000 birds in 2016. These flocks, mostly of Pochards and Tufted Ducks, were concentrated three and more kilometers from the shore and, despite using the best vantage point (lighthouse) and a spotting scope, we were unable, except in January 2014, to identify and count the species separately. Therefore, actual numbers of wintering Pochard and Tufted Duck can be even higher than listed in our report.

Diverse types of vast natural and artificial wetland habitats, as well as agricultural fields of Krasnodar Province can provide good roosting and feeding conditions for wintering swans, geese, ducks and other waterbirds. After waterfowl hunting closing on 31st December, disturbance is relatively low, and mild weather becomes an important factor for wintering waterbirds to concentrate in the area. However, the construction of houses and infrastructure development at the sea coasts lead to the destruction of some important wetland sites and therefore pose serious threats on wintering waterbirds.

Acknowledgements. We thank Wetlands International and the Ministry of Natural Resources of Krasnodar Province for support of the mid-winter counts. We are also grateful to Roman Mnatsekanov, Petr Tilba, Mikhail Dinkevich, Murat Emtyl, Timur Korotkiy, Alexander Goshko, Olga Bykhalova, Alla Lokhman and Lev Shagarov for participation in the field surveys in different years.

6. Zusammenfassung

Solokha, A. & Y. Lokhman 2017: Bestände und Verbreitung überwinternder Wasservögel in der Provinz Krasnodar, Südwest-Russland. Vogelwelt 137: 156–161.

Die Region Krasnodar umfasst große Küstenbereiche des Schwarzen und Asowschen Meeres sowie eine Vielzahl von Binnengewässern die, gerade in milden Wintern, ein wichtiges Überwinterungsgebiet für Wasservögel darstellen. Seit 2003 beteiligt sich die Region an der International Wasservogelzählung (IWC), die – mit Ausnahme der Jahre 2007–2009 – seither jährlich durchgeführt wird. Die Zählgebietsabdeckung variiert und ist in erster Linie von der Verfügbarkeit der Feuchtgebiet für Wasservögel abhängig (ob diese zugefroren sind oder nicht). Insgesamt wurden 37 Zählgebiete zumindest einmal zwischen 2003 und 2016 gezählt. Die Zählungen wurden vom Festland oder Boot durchgeführt. Wegen der geringen Anzahl an qualifizierten Zählern und der Vielzahl an Feuchtgebieten bzw. relevanter Wasserflächen konnte bisher keine simultane Erfassung in allen Zählgebieten stattfinden. Der Zeitraum für die jährlichen Zählungen wurde jedoch so kurz wie möglich gehalten, mit dem Ziel alle Gebiet jeweils zwischen dem 10. und 25. Januar eines Jahres zu erfassen. Die größte Abdeckung wurde 2004 mit 27 Zählgebieten erreicht. Die Gesamtzahl der erfassten Wasservögel variierte zwischen 145.614 Individuen im Jahr 2003 und 1.112.213 Individuen 2013. Der höchste Bestand in einem einzelnen Zählgebiet (353.982 Ind.) wurde 2013 in der Taman Bucht erfasst. Insgesamt wurden im Rahmen der Zählungen bisher 74 Wasservogelarten festgestellt. Die häufigsten Arten waren dabei Stockente (höchster Gesamtbestand 396.920 Individuen im Jahr 2013), Lachmöwe (243.615 Ind., 2013), Blässhuhn (147.390 Ind., 2011), Reiherente (137.839 Ind., 2014) und Tafelente (106.069 Ind., 2013). Höcker- und Singschwan, Stockente, Lachmöwe, Reiherente und Tafelente zeigten starke oder moderate Zunahmen über den Zeitraum 2003–2016. Unter den überwinternden Wasservögeln waren auch vier weltweit als gefährdet eingestufte Arten (Krauskopfpelikan, Zwerggans, Rothalsgans, Weißkopf-Ruderente). Neben mildem Wetter ist insbesondere ein geringes Störungsniveau im Januar ein kritischer Faktor im Hinblick darauf, ob Wasservögel längerfristig in der Region Krasnodar verweilen. Leider kommt es durch zunehmende Infrastrukturentwicklung und den Neubau von Häusern entlang der Küste zur Degradierung einiger wichtiger Überwinterungshabitate.

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Bird dynamics in two wetlands of the Prut River basin (Romania and Moldova) during the wintering time

Silvia Ursul & Carmen Gache

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Our study was done during the period 2012 – 2015, using the fixed point census method in two IBAs of the Prut River basin: Jijia and Miletin ponds (Romania) in the middle sector of the river, respectively, Manta-Beleu lakes (Moldova) in the lower sector. We recorded 75 bird species in the first area and 83 species in the second one. During the entire wintering period we focused our attention on the presence of wintering waterfowl and raptor in both IBAs. There were 14 species recorded on the Miletin-Jijia ponds, while 47 were present on the Manta-Beleu lakes. From these, 13 bird species are regarded as late migrants in the areas, being present just in November. Three recorded wintering bird species are globally threatened: White-tailed Eagle as resident, while the Pygmy Cormorant and Red-breasted Goose appear just on passage, especially till the December time.

The big difference in the bird diversity recorded in the investigated IBAs is due to their geographic location. The Manta-Beleu lakes are situated close to the Danube Delta, representing a bottle-neck that leads to large concentrations of waders and waterfowl. The area offers suitable feeding resources and resting habitats for the wintering birds. 24 bird species are listed in Annexe 1 of EU Birds' Directive, 10 of them being included both in the Romanian and Moldavian Red Books, too.

Keywords: Prut River, wintering time, wetlands, IBAs

1. Introduction

The protection and conservation of biodiversity requires, first of all, a good assessment of species populations, including their trends, and also of the environmental problems which influence the population status. Based on the data provided by these assessments and studies, a wide range of conservation activities can be carried out: straightening, expanding of conservation networks, or protection measurements for certain species.

The widest habitat conservation network is the Important Bird Areas program (IBA), which acts like an umbrella for monitoring and research of avifauna in the regions covered by this network. Being present in 200 countries and consisting of 12,000 important bird areas, this program, implemented by BirdLife International, becomes the most powerful conservation strategy designed for habitat and bird fauna's diversity. A special and very important type of IBA, which impresses through overwhelming species diversity, are wetlands – islands of semi-wilderness where the abundance of trophic resources and the large diversity of habitats gather impressive bird numbers with different conservation status. Because of the large diversity of species, their multiple environmental aspects and permanent seasonal fluctuations, wetlands studies are important and needed.

In this regard, the present paper aims to show a comparative study carried out in two important bird areas of the Prut River catchment (which represents the border between Romania and the Republic of Moldova). The IBA „Jijia and Miletin ponds" is located in Romania, in the middle basin of the Prut River (Papp & Fantana 2008), while the IBA „Manta-Beleu lakes" is situated in the Republic of Moldova, in the lower course of the same river. The first IBA is the result of a large hydro-technical work done in the early 1970s on the confluence area of Jijia and Miletin Rivers, used like traditional extensive fisheries, while the second IBA is a natural wetland, created after periodical flooding of the river. The „Manta-Beleu" area is also a Ramsar site established in 1991 (Criteria 2 on vulnerable species, and Criteria 3 on biodiversity). The similarity of habitats and the aquatic/semi-aquatic bird diversity at both sites represented the starting point for a joint study focusing our attention on the wintering time characteristics in these two aquatic ecosystems.

2. Methods and materials

Our study was carried out simultaneously in both IBAs between autumn 2013 and spring 2015 (Fig. 1, 2a, 2b). Fieldwork was conducted according to the phenological seasons,

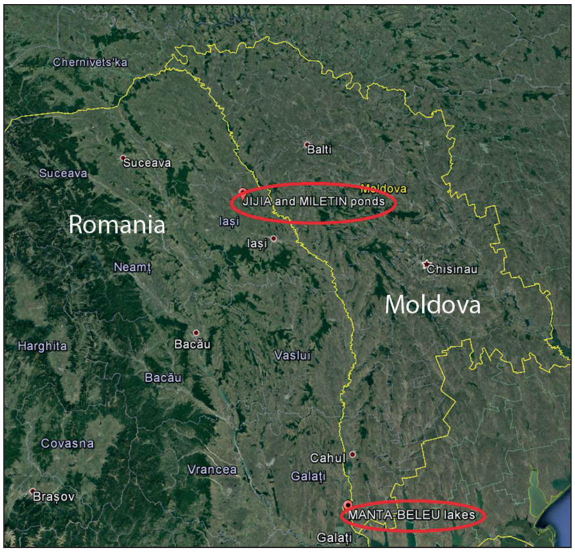

Fig. 1: „Jijia and Miletin ponds" and „Manta-Beleu lakes": the two IBAs from the Prut River basin in which the study was conducted. – *„Jijia und Miletin Teiche" und „Manta-Beleu Seen": die zwei IBAs des Einzugsgebietes des Flusses Pruth, in denen die Studie durchgeführt wurde.*

with monthly visits at both sites during wintering and breeding season, and more frequent visits during the migration period (twice per month). The methods most commonly used during the entire study were line-transect counts combined with point-counts.

Since our study aimed at inventorying the ornithological diversity of two important bird areas (which are also important wetlands), we focused our two years of fieldwork on the species which are strongly connected to this type of habitats. In this regard, we paid attention to aquatic species groups (Podicepediformes, Sulifomes, Pelecaniformes, Anseriformes, Gruiformes) and waders (Charadriiformes), but also to bird species with similar ecological needs (Ciconiiformes, Coraciiformes and Passerifomes). Nevertheless, we considered it necessary to study the presence of raptor species in both IBAs, as many of them can be seen in the vicinity of wetlands (Marsh Harrier *Circus aeruginosus*, Osprey *Pandion haliaetus*) and are regarded as top consumers in these ecosystems.

3. Results and discussions

During the entire study, we created a species list which turned out to be relatively similar in both IBAs. We registered 75 species in the „Jijia and Miletin ponds" IBA and 83 in the „Manta-Beleu lakes" IBA (Table 1). For a better representation of bird species' diversity in both IBAs during the wintering time, the symbols „+" and „-" were used in Table 1 to indicate the species presence/absence in both IBAs. Moreover, the list shows the conservation status according to SPEC (Species of European Conservation Concern) and IUCN (International Union for Conservation of Nature) assessments, as well as the current status mentioned by the Romanian Red Book (Botnariuc & Tatole 2005) and the Moldovan Red Book (Duca *et al.* 2015). Due to the fact that the overall study was conducted in two different countries, the phenological status for some species differs depending on the data available in each country and the period in which these species were observed.

The wintering season usually is characterized by a low diversity of bird species (Gache 2002). This is mainly a result of unfavourable weather conditions, being responsible for low temperatures which determine the complete freezing of the lakes. Thus, in both IBAs only bird species highly adapted to harsh winter conditions were recorded.

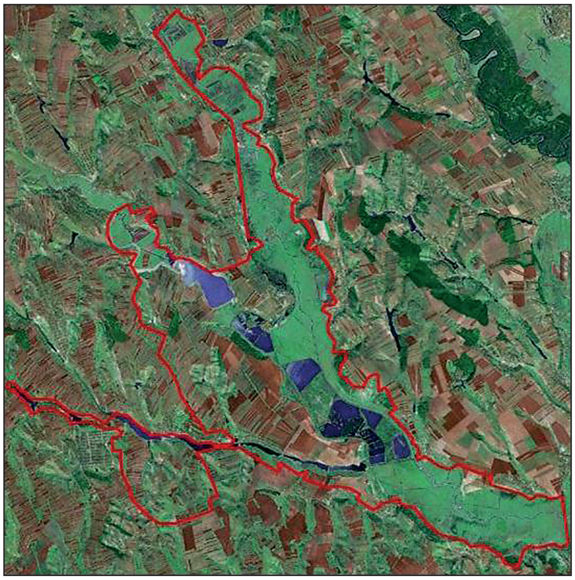

Fig. 2a: The „Miletin and Jijia ponds" IBA. – *Das IBA „Jijia und Miletin Teiche".*

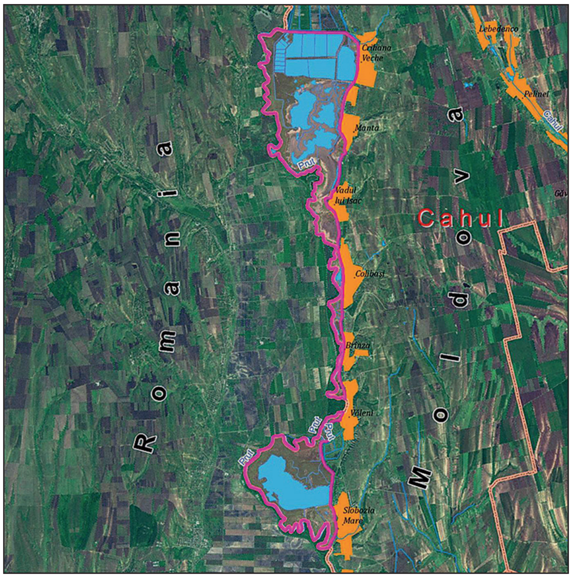

Fig. 2b: „The Manta-Beleu lakes" IBA. – *Das IBA „Manta-Beleu Seen".*

During the wintering season we recorded 14 species on the Miletin-Jijia ponds, while 47 species were present on the Manta-Beleu lakes. The Manta-Beleu lakes are situated close to the Danube Delta, representing a bottle-neck that lead to large concentrations of waders and waterfowl. Accordingly, we focused our attention, besides the usual wintering species, on species considered to represent late migrants, being present as passage species during November-December.

Among the wintering species common at Jijia and Miletin ponds were Whooper Swan *Cygnus cygnus* with individuals using the place as a wintering site. Also, we noticed medium-sized flocks of White-fronted Geese *Anser albifrons*, together with some individuals of Red-breasted Goose *Branta ruficollis*. Goshawk *Accipiter gentilis*, White-tailed Eagle *Haliaeetus albicilla* and Common Buzzards *Buteo buteo* were the most common raptors identified during the winter period, while the Hen Harrier *Circus cyaneus* was observed only once. Although regarded as late migrants, Rough-legged Buzzard *Buteo lagopus* and Pallid Harier *Circus macrourus* were frequently observed during December and January. Coot *Fulica atra* as well as Black-headed Gulls *Larus ridibundus* were present in the area in large numbers (flocks up to 1,880 individuals).

At Manta-Beleu lakes the diversity of migrating and wintering species was visible larger, as there were frequently records of Whooper Swan, Pintail *Anas acuta*, Teal *Anas crecca*, Tufted Duck *Aythya fuligula*, Goosander *Mergus merganser*, White-fronted Goose, Little Tern *Sternula albifrons*, Red-breasted Goose, the latter in mixed flocks with White-fronted Geese.

In the early wintering season, during November, we recorded late migrating species such as Goldeneye *Bucephala clangula*, Wigeon *Anas penelope*, Garganey *Anas querquedula*, Golden Plover *Pluvialis apricaria*, Little Ringed Plover *Charadrius dubius*, Ruff *Philomachus pugnax*, Dunlin *Calidris alpina*, Little Stint *Calidris minuta*, Snipe *Gallinago gallinago*, Curlew *Numenius arquata*, Spotted Redshank *Tringa erythropus*, Wood Sandpiper *Tringa glareola*, Green Sandpiper *Tringa ochropus*, Redshank *Tringa totanus*, Avocet *Recurvirostra avosetta* and Little Gull *Hydrocoloeus minutus*. All these species continued to gather also during December in this pre-deltaic ecosystem, marking very late autumn migration.

We notice the presence of Merlin *Falco columbarius* and Peregrine *Falco peregrinus*. The Common Buzzard is a frequent species during the wintering season in the entire area.

In addition, we recorded some partially migratory species in this IBA, which are absent during specific times of the year or whose population numbers fluctuate during the cold season. The most constant species was the Mute Swan *Cygnus olor* being present across the entire year at Manta-Beleu lakes, although the wintering population was significantly smaller than peak numbers on spring

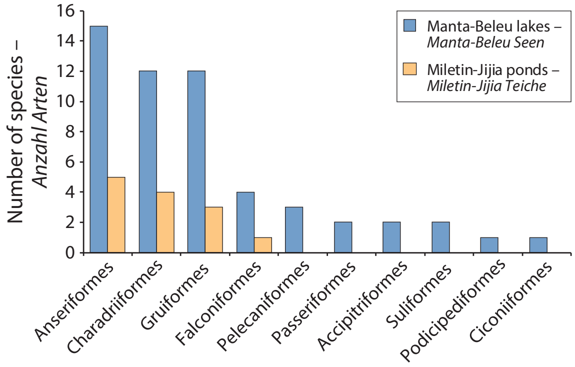

Fig. 3: Comparative bird diversity (in number of species per order) during winter in the „Jijia and Miletin ponds" IBA and „Manta-Beleu lakes" IBA. – *Vergleich der Vogelartendiversität (Anzahl der Arten je Ordnung) im IBA „Jijia und Miletin Teiche" und IBA „Manta-Beleu Seen" im Winter.*

migration (flocks of 30-180 individuals during winter compare to up to 1,160 individuals during a single spring migration day in March). Unlike the Mute Swan, numbers of Mallard *Anas platyrhynchos* and Greylag Goose *Anser anser*, were remarkably higher during the winter months, forming flocks of about 8,000 individuals (*A. platyrhynchos*) or 1,500 individuals (*A. albifrons*). Among the common passerines for wetlands, we noticed few individuals of Penduline Tit *Remiz pendulinus* (2-5), Reed Bunting *Emberiza schoeniclus* (1-3) and Bearded Tit *Panurus biarmicus* (1-5). Last but not least, sedentary species such as Goshawk, Sparrowhawk *Accipiter nisus*, Kestrel *Falco tinnunculus*, Coot, Black-headed Gull and Yellow-legged Gull *Larus cachinnans/michachellis* were also observed spending their winter at the „Manta-Beleu lakes" IBA.

The total numbers of migrating and wintering species encountered during the wintering season in both Important Bird Areas and the taxonomic differences observed are illustrated in Fig. 3.

Regarding the conservation status, two of the species recorded were considered as endangered at the time of our study: White-tailed Eagle and Pygmy Cormorant *Phalacrocorax pygmeus*. Being resident in both sites, we observed 1-3 individuals of White-tailed Eagle during December, January and February, hunting around the big agglomerations of birds gathered on lakes. The Pygmy Cormorant was only observed on the Manta-Beleu lakes during December; we believe that the birds are present just for short periods coming for feeding purposes from the Danube Delta. In 2016, the status of these species has changed from endangered to least concern (LC).

The only currently endangered species observed during our study is the Red-breasted Goose, appearing at „Jijia and Miletin ponds" on passage during December, and occasionally observed at Manta-Beleu lakes probably because their roosting sites (Romanian and Ukrainian fields around Danube Delta) were situated very close to our counting stations (30–40 km).

Table 1: Taxonomic list of the species inventoried on the "Manta-Beleu lakes" IBA and "Jijia and Miletin ponds" IBA. – *Taxonomische Artenliste der im IBA „Manta-Beleu Seen" und IBA „Jijia und Miletin Teiche" erfassten Arten.*

No.	Species – *Art*	IBA „Manta-Beleu lakes" – *IBA "Manta-Beleu Seen"*	IBA „Jijia-Miletin ponds" – *IBA "Jijia und Miletin Teiche"*	Red Book (R. Moldova) – *Rote Liste (Republik Moldau)*	Red Book (Romania) – *Rote Liste (Rumänien)*	IBA Criteria – *IBA Kriterien*	IUCN	Birds Directive – *EU Vogelschutzrichtlinie*	SPEC
1.	Cormorant *Phalacrocorax carbo*	+	+	-	-	A4/B1	LC	-	Non-SPEC
2.	Pygmy Cormorant *Phalacrocorax pygmeus*	+	+	CR	VU	A1; A4/B1	LC	I	Cat. 2
3.	Little Egret *Egretta garzetta*	+	+	-	P	A4/B1	LC	I	Non-SPEC
4.	Grey Heron *Ardea cinerea*	+	+	-	-	A4/B1	LC	-	Non-SPEC
5.	Great White Egret *Casmerodius albus*	+	+	EN	EN	A4/B1	LC	I	Non-SPEC
6.	White Stork *Ciconia ciconia*	+	+	VU	VU	A4/B1; B2	LC	I	Cat 2
7.	Mute Swan *Cygnus olor*	+	+	VU	-	A4/B1	LC	II/2	Cat 3
8.	Whooper Swan *Cygnus cygnus*	+	+	VU	-	A4/B1	LC	I	Cat 4
9.	Tufted Duck *Aythya fuligula*	+	+	-	-	A4/B1	LC	II/1; III/2	Non-SPEC
10.	Greater Scaup *Aythya marila*	-	+	-	-	A4/B1; B2	LC	II/2; III/2	Cat 3
11.	Gadwall *Anas strepera*	+	+	-	-	A4/B1; B2	LC	II/1	Cat 3
12.	Shoveler *Anas clypeata*	+	+	-	-	A4/B1	LC	II/1; III/2	Non-SPEC
13.	Pintail *Anas acuta*	+	+	-	-	A4/B1	LC	II/1; III/2	Non-SPEC
14.	Teal *Anas crecca*	+	+	-	-	A4/B1	LC	II/1; III/2	Non-SPEC
15.	Wigeon *Anas penelope*	+	+	-	-	A4/B1	LC	II/1; III/2	Non-SPEC
16.	Mallard *Anas platyrhynchos*	+	+	-	-	A4/B1	LC	II/1; III/1	Non-SPEC
17.	Goldeneye *Bucephala clangula*	+	-	-	VU	A4/B1	LC	II/2	Non-SPEC
18.	Goosander *Mergus merganser*	+	-	-	-	Non-IBA	LC	II/2	Non-SPEC
19.	Ruddy Shelduck *Tadorna ferruginea*	+	-	VU	CR	A4/B1; B2	LC	I	Cat 3

No.	Species – *Art*	IBA „Manta-Beleu lakes" – *IBA "Manta-Beleu Seen"*	IBA „Jijia-Miletin ponds" – *IBA "Jijia und Miletin Teiche"*	Red Book (R. Moldova) – *Rote Liste (Republik Moldau)*	Red Book (Romania) – *Rote Liste (Rumänien)*	IBA Criteria – *IBA Kriterien*	IUCN	Birds Directive – *EU Vogelschutzrichtlinie*	SPEC
20.	Shelduck *Tadorna tadorna*	+	+	VU	VU	A4/B1	LC	-	Non-SPEC
21.	Greylag Goose *Anser anser*	+	+	-	-	A4/B1	LC	II/1; III/2	Non-SPEC
22.	White-fronted Goose *Anser albifrons*	+	+	-	-	A3; A4/B1	LC	I; II/2; III/2	Non-SPEC
23.	Red-breasted Goose *Branta ruficollis*	+	+	VU	EN	A1; A4/B1	EN	I	Cat 1
24.	Sparrowhawk *Accipiter nisus*	+	+	-	-	Non-IBA	LC	I	Non-SPEC
25.	Marsh Harrier *Circus aeruginosus*	+	+	-	-	A4/B1; B2	LC	I	Non-SPEC
26.	Hen Harrier *Circus cyaneus*	+	+	CR	-	Non-IBA	LC	I	Cat 3
27.	Montagu's Harrier *Circus pygargus*	-	+	CR	EN	Non-IBA	LC	I	Non-SPEC
28.	White-tailed Eagle *Haliaeetus albicilla*	+	+	CR	CR	A4/B1; B2	LC	I	Cat 3
29.	Common Buzzard *Buteo buteo*	+	+	-	-	A4/B1	LC	III	Non-SPEC
30.	Rough-legged Buzzard *Buteo lagopus*	+	+	-	-	Non-IBA	LC	III	Cat 3
31.	Merlin *Falco columbarius*	+	-	-	-	A4/B1	LC	I	Non-SPEC
32.	Peregrine *Falco peregrinus*	+	-	EN	EN	Non-IBA	LC	I	Non-SPEC
33.	Kestrel *Falco tinnunculus*	+	+	-	-	A4/B1; B2	LC	-	Cat 3
34.	Coot *Fulica atra*	+	+	-	-	A4/B1	LC	II/1; III/2	Non-SPEC
35.	Moorhen *Gallinula chloropus*	+	+	-	-	A4/B1	LC	II/2	Non-SPEC
36.	Golden Plover *Pluvialis apricaria*	+	+	-	-	A4/B1; B3	LC	I; II/2; III/2	Non-SPEC
37.	Lapwing *Vanellus vanellus*	+	+	-	-	A4/B1	NT	II/2	Non-SPEC
38.	Ruff *Philomachus pugnax*	+	+	-	-	A4/B1; B3	LC	I; II/2	Cat 4
39.	Dunlin *Calidris alpina*	+	+	-	-	A3; A4/B1	LC	I	Cat 3

No.	Species – *Art*	IBA „Manta-Beleu lakes" – *IBA "Manta-Beleu Seen"*	IBA „Jijia-Miletin ponds" – *IBA "Jijia und Miletin Teiche"*	Red Book (R. Moldova) – *Rote Liste (Republik Moldau)*	Red Book (Romania) – *Rote Liste (Rumänien)*	IBA Criteria – *IBA Kriterien*	IUCN	Birds Directive – *EU Vogelschutzrichtlinie*	SPEC
40.	Green Sandpiper *Tringa ochropus*	+	-	-	-	A4/B1	LC	-	Non-SPEC
41.	Spotted Redshank *Tringa erythropus*	+	+	-	-	A3; A4/B1	LC	-	Non-SPEC
42.	Avocet *Recurvirostra avosetta*	+	+	VU	VU	A4/B1; B2; B3	LC	I	Non-SPEC
43.	Black-headed Gull *Larus ridibundus*	+	+	-	-	A4/B1	LC	-	Non-SPEC
44.	Common Gull *Larus canus*	+	-	-	-	A4/B1; B2	LC	II/2	Cat 2
45.	Little Gull *Hydrocoloeus minutus*	+	+	-	-	A4/B1; B2	LC	I	Cat 3
46.	Yellow-legged Gull *Larus cachinnans/ michahellis*	+	+	-	-	A4/B1	LC	II/2	Non-SPEC
47.	Little Tern *Sternula albifrons*	+	-	-	-	Non-IBA	LC	I	Cat 3
48.	Bearded Tit *Panurus biarmicus*	+	+	-	-	Non-IBA	LC	-	Non-SPEC
49.	Penduline Tit *Remiz pendulinus*	+	+	-	-	Non-IBA	LC	-	Non-SPEC
50.	Reed Bunting *Emberiza schoeniclus*	+	+	-	-	Non-IBA	LC	-	Non-SPEC

SPEC – Species of European Conservation Concern: SPEC 1 – Species of global conservation concern, i.e. classified as globally threatened, Near Threatened or Data Deficient; SPEC 2 – Concentrated in Europe and with an Unfavourable Conservation Status; SPEC 3 – Not concentrated in Europe but with an Unfavourable Conservation Status; Non-SPEC – Not concentrated in Europe and with a Favourable Conservation Status. – ***SPEC*** *– Arten von europäischer Bedeutung für den Naturschutz: SPEC 1 – Arten von weltweiter Bedeutung für den Naturschutz, z. B. als weltweit gefährdet, potenziell gefährdet eingestufte Arten oder Arten mit ungenügende Datengrundlage; SPEC 2 – In Europa konzentriert und mit schlechtem Erhaltungszustand; SPEC 3 – Nicht in Europa konzentriert und mit schlechtem Erhaltungszustand; Non-SPEC – Nicht in Europa konzentriert und mit gutem Erhaltungszustand.*

IUCN – International Union for Conservation Nature: LC – Least Concern; NT – Near Threatened; VU – Vulnerable; EN –Endangered. – ***IUCN*** *– Weltnaturschutzunion: LC – nicht gefährdet; NT – potenziell gefährdet; VU – gefährdet; EN – stark gefährdet.*

IBA Criteria: A1 – globally threatened species; A3 – species of restrictive biome; A4/B1 – bird species forming great agglomerations in different periods of the year (breeding season, migration, wintering time); B2 – species with unfavourable conservation status in Europe; B3 – species with favourable conservation status in Europe. – ***IBA Kriterien:*** *A1 – weltweit gefährdete Art; A3 – Art mit begrenztem Biom; a4/B1 – Vogelarten die während bestimmter Perioden des Jahres große Ansammlungen bilden (Brutzeit, Zugzeit, Überwinterungsperiode); B2 – Arten mit schlechtem Erhaltungszustand in Europa; B3 – Arten mit gutem Erhaltungszustand in Europa.*

Birds Directive: Directive 2009/147/EC. – ***EU Vogelschutzrichtlinie:*** *Direktive 2009/147/EC.*

Romanian Red Book of Vertebrates: EN – endangered species; VU – vulnerable species; CR – critically threatened species. – ***Rumänische Rote Liste der Wirbeltiere:*** *EN – stark gefährdet; VU – gefährdet; CR – vom Aussterben bedroht.*

Republic of Moldova Red Book: VU – vulnerable species; CR – critically threatened species. – ***Rote Liste der Republik Moldau:*** *VU – gefährdet; CR – vom Aussterben bedroht.*

4. Conclusions

The present study, conducted during 2013–2015 in two IBAs from the Prut River catchment, confirms the role of both sites as migration and wintering areas for different ecological groups of birds.

Although the species diversity during the wintering season was low in both IBAs (14 species on the „Jijia and Miletin ponds", respectively, 47 on the „Manta-Beleu lakes"), the numbers passing through these places reconfirm the migration routes along the Prut River to the bottle-neck represented by the Danube Delta.

At the same time, these two Important Bird Areas represent important stopover sites during the migration periods.

The presence of large aquatic habitats recommends both as important wetlands in the basin of the Prut River and the Danube River.

5. Zusammenfassung

Ursul, S. & C. Gache 2017: Wintervogelbestände in zwei Feuchtgebieten im Einzugsgebiet der Flusses Pruth (Rumänien und Moldawien). Vogelwelt 137: 162–168.

Der Beitrag berichtet über die Wintervogelbestände im Einzugsgebiet der Flusses Pruth, der dem Verlauf der moldawisch-rumänischen Grenze folgt. Die Vogelbestände in zwei „Important Bird Areas" (IBAs), dem IBA „Jijia und Miletin Teiche" (Rumänien) im mittleren Sektor des Flusses und dem IBA „Manta-Beleu Seen" (Republik Moldau) im Unterlauf, wurden im Zeitraum 2012-2015 von definierten Punkten aus erfasst. Insgesamt wurden im erstgenannten IBA 75 Vogelarten und im zweigenannten 83 Vogelarten festgestellt. Während der gesamten Überwinterungsperiode lag der Fokus der Erfassungen in beiden IBAs insbesondere auf überwinternden Wasservögeln und Greifvögeln. An den Jijia und Miletin Teiche konnten 14 Arten und an den Manta-Beleu Seen 47 Arten aus diesen beiden Artengruppen nachgewiesen werden. 13 dieser festgestellten Arten sind als Spätzieher zu bezeichnen, die nur im November in den Gebieten anwesend waren. Drei festgestellte überwinternde Arten, der Seeadler als Standvogel sowie Zwergscharbe und Rothalsgans als Durchzügler, die bis in den Dezember hinein auftreten, werden weltweit als gefährdet eingestuft.

Die großen Unterschiede im Hinblick auf die Artenvielfalt innerhalb der beiden untersuchten IBAs sind durch ihre geographische Lage zu erklären. Die Manta-Beleu Seen befinden sich in der Nähe des Donaudeltas, einer Art Flaschenhals des Vogelzugs, was zu großen Konzentrationen von Wat- und Wasservögeln führt. Das Gebiet hält geeignete Nahrungsressourcen und Rasthabitate für überwinternde Vögel bereit und 24 der dort festgestellten Arten sind in Anhang I der EU Vogelschutzrichtlinie gelistet, von denen zehn Arten auch in den Roten Listen Rumäniens sowie der Republik Moldau geführt werden.

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Overlap between breeding season distribution and wind farm risks: a spatial approach

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While the interactions between wind turbines and birds have been studied comprehensively in recent years, large scale assessments on likely effects of the current development status of the wind energy sector on sensitive species are often missing. To mitigate wind farm related risks for birds, the Working Group of German State Bird Conservancies published species-specific minimum distances of wind turbines to breeding sites that should be kept free from turbines. Using these recommendations the overlap between the breeding distribution and areas of wind farm related risks was estimated as well as the proportions of bird populations potentially influenced by the current state of wind energy production. The assessment was carried out based on the distribution and abundance information of the recently published second Atlas of German Breeding Birds, land use information of the Corine Land Cover data base and location information for operational onshore wind turbines on German territory. The results indicate a considerable overlap between the breeding season habitat and areas of wind farm related risks for various sensitive species. Especially the group of open landscape species regularly face potential disturbance of 9 to 13 % of their breeding season habitat. For individual species, often with only regional distribution in Germany, even considerable higher potential habitat disturbance figures are found with values up to 55 %. For most species, values for percentage habitat disturbance and estimates on the proportion of the national population to be influenced by wind turbines were relatively similar.

Keywords: wind turbines, potential habitat disturbance, distance recommendations, sensitive species, overlap

1. Introduction

In 2015 gross wind energy production, on- and offshore, accounted for 13.3 % of the energy production in Germany and while there is a recent strong increase in wind energy generated offshore, the majority of wind energy is produced by nearly 26,000 onshore wind turbines (strom-report.de).

The effects onshore wind turbines impose on various bird species have been studied comprehensively in recent years and collision risk, habitat loss due to displacement and barrier effects have been identified as key impacts (e.g. Percival 2005, Drewitt & Langston 2006, Pearce-Higgins *et al.* 2012, Bellebaum *et al.* 2013). To mitigate wind farm related risks for birds, the Working Group of German State Bird Conservancies (LAG VSW) defined species-specific core activity zones around nesting sites that should be kept free from onshore wind turbines. These distance recommendations were informed by knowledge on species-specific sensitivity and home range size during the breeding season. Moreover, density hotspots of sensitive species should receive increased attention during the planning and approval process for wind turbines to secure source populations (LAG VSW 2014).

These species-specific distance recommendations should be considered at the planning stage and were used to estimate the overlap between potential breeding season habitats (breeding as well as foraging habitat during the breeding season) of sensitive species and areas of increased disturbance potential due to wind energy production. The assessment is based on the assumption that wind turbine related risks, respectively habitat devaluation, is likely to occur within the recommended distances irrespective of whether such zones around wind turbines are used as nesting sites or foraging habitat.

Species-specific breeding distribution was defined based on data of the recent Atlas of German Breeding Birds (Gedeon *et al.* 2014) and potential habitat within the respective distributional range determined using Corine Land Cover classes (CLC 2012). Wind turbine locations were buffered by species-specific distance recommendations to estimate the percentage spatial overlap between habitats and wind farm risk areas. This allows a cumulative assessment of the habitat disturbance associated with wind energy production across the entire German breeding range of sensitive species.

2. Data and methodology

The study assessed the overlap between breeding season habitat and wind farm related risks for those species identified by LAG VSW to be sensitive to wind farms (see Table 1) based on the assumption that wind turbines impose certain risks (displacement, collision, barrier effect) on these species within the recommended species-specific distances. A similar spatial analysis approach was followed e.g. by Telleria (2009). Moreover, population percentages potentially affected (not impacted) were estimated.

2.1 Breeding season distribution

The Atlas of German Breeding Birds (Gedeon *et al.* 2014) allows a precise definition of the current breeding season distribution of birds in Germany. The atlas is based on data collected between 2005 and 2009 and provides information on presence and absence of species as well as their abundance at the spatial resolution of the topographic map 1 : 25,000 (grid cells measuring approx. 11 x 11 km). Species abundance classes are provided for each grid cell.

2.2 Species-specific habitat classes

Individual species show specific habitat preferences and accordingly do not occur everywhere within the grid cells identified by Gedeon *et al.* (2014) as populated/occupied. To better understand the potential distribution within individual grid cells and identify potential habitats with relevance for the respective species, land use information was obtained. We used the Corine Land Cover (CLC) 2012 data set, providing land cover information at a geographic accuracy of 25 ha minimum mapping units and 100 m minimum mapping width (EEA 2007). For each species all CLC classes used to describe German territory were divided in those representing potential habitat for the respective species and those where regular usage for foraging or nesting appeared unlikely. This assignment process was informed by the Methodological Manual for Surveying Breeding Birds in Germany (Südbeck *et al.* 2005), listing typical habitats for each species, the result of a research and development project carried out by the Federation of German Avifaunists (DDA) defining ecological bird gilds (Wahl *et al.* 2014) and expert judgments.

This assignment process led to the exclusion of a few species from the assessment. For Osprey *Pandion haliaetus* and White-tailed Eagle *Haliaeetus albicilla* for example a suitable assignment of CLC classes to define the breeding season habitat was not feasible. Both species are strongly related to (especially inland) water bodies, but can breed in various kinds of habitats as long as suitable natural or artificial structures for nesting are available, and they overfly various habitats when commuting between breeding and foraging sites. Accordingly, it would be difficult to discard CLC classes to potentially represent habitat probably aside of strongly urbanized areas, while in fact the species are unlikely to regularly occur at larger distances of water bodies during the breeding season. Also Bittern *Botaurus stellaris* and Little Bittern *Ixobrychus minutus* were excluded for methodological reasons. For both species it was not always possible to indicate suitable habitats based on the CLC classes, leading to situations where Gedeon *et al.* (2014) indicates a breeding season occurrence in a particular grid cells, while those CLC classes identified to represent Bittern habitat (e.g. inland marshes and peat bogs) did not occur within those grid cells. Accordingly, the chosen approach was not suitable to identify and narrow down the potential breeding season habitat, likely because both species of bittern sometimes inhabit habitat patches too small to be mapped at CLC resolution.

Moreover, colonial breeding heron, gull and tern species, listed as sensitive to wind turbines (LAG VSW 2014), were excluded from the assessment, because the chosen approach was not deemed suitable to consider the strong concentrations of colonial breeding species in limited sectors of potentially suitable habitats as indicated by the CLC classes.

Nonetheless, it was possible to narrow down the potential breeding season habitats for 30 species for which minimum distances to wind turbines have been recommended. Table 2 illustrates the results of this assignment process for a few example species.

2.3 Wind farm locations and buffers

Based on these species-specific distance recommendations (LAG VSW 2014; see Table 1) the overlap between potential breeding season habitat and areas of increased risks due to wind energy can be assessed under the precondition that sufficient information on the wind turbine locations is available.

Geographic coordinates of wind turbine locations were enquired from the respective responsible authorities of all German federal states and data were obtained from all states with the exception of Berlin, where only single wind turbines have been built. The currentness of data (12/2014 to 01/2016), status information and data format differed considerably among the federal states. After combining and synchronizing data sets the locations of 24,011 operational onshore wind turbines could be visualized in the Geographic Information System (GIS). The German Agency for Renewable Energy (AEE) names a number of 25,821 onshore turbines in Germany by the end of 2015 (AEE 2016), without explicitly stating that all of these would be operational. Assuming this, we were able to collate point data for about 93 % of the operational onshore wind turbines (status 2015).

In a next step the wind turbine locations were buffered by species-specific distance recommendations, to identify those areas of potential habitat devaluation. By overlaying potential habitat within breeding season distribution with wind turbine buffers the spatial overlap between habitat and wind farm risk areas was estimated.

This allowed a cumulative assessment of the habitat disturbance potential associated with wind energy production across the entire German breeding range of sensitive species. Based on the species-specific percentage potential habitat disturbance calculated for each grid cell populated by the respective species it was possible to roughly estimate the proportion of the populations of sensitive species likely to be influenced by the presence of wind turbines. Therefore we calculated the geometric mean of the abundance

Table 1: Overview on recommended minimum distances of wind turbines to breeding sites of bird species sensitive to wind turbines. In brackets recommended ranges of verification around wind farms for frequently used feeding sites, roosts or other significant habitats (based on LAG VSW 2014). – *Übersicht über fachlich empfohlene Mindestabstände von Windenergieanlagen (WEA) zu Brutplätzen bzw. Brutvorkommen WEA-sensibler Vogelarten. Der in Klammern gesetzte Prüfbereich beschreibt Radien, innerhalb derer zu prüfen ist, ob Nahrungshabitate, Schlafplätze oder andere wichtige Habitate der betreffenden Art bzw. Artengruppe vorhanden sind, die regelmäßig angeflogen werden (basierend auf LAG VSW 2014).*

Species, species group – ***Art, Artengruppe***	**Minimum distance of wind turbines (range of verification) –** ***Mindestabstand der WEA (Prüfbereich in Klammern)***
Grouse species – *Raufußhühner*: Capercaillie *Tetrao urogallus*, Black Grouse *Tetrao tetrix*, Hazel Grouse *Tetrastes bonasia*, Ptarmigan *Lagopus muta*	1,000 m around areas of occurrence; corridors between neighbouring areas of occurrence should be kept free. – *1.000 m um die Vorkommensgebiete; Freihalten von Korridoren zwischen benachbarten Vorkommensgebieten.*
Bittern *Botaurus stellaris*	1,000 m (3,000 m)
Little Bittern *Ixobrychus minutus*	1,000 m
Black Stork *Ciconia nigra*	3,000 m (10,000 m)
White Stork *Ciconia ciconia*	1,000 m (2,000 m)
Osprey *Pandion haliaetus*	1,000 m (4,000 m)
Honey-buzzard *Pernis apivorus*	1,000 m
Golden Eagle *Aquila chrysaetos*	3,000 m (6,000 m)
Lesser-spotted Eagle *Aquila pomarina*	6,000 m
Hen Harrier *Circus cyaneus*	1,000 m (3,000 m)
Montagu's Harrier *Circus pygargus*	1,000 m (3,000 m); density hotspots should be considered irrespective of the current location of breeding sites. – *Dichtezentren sollten insgesamt unabhängig von der Lage der aktuellen Brutplätze berücksichtigt werden.*
Marsh Harrier *Circus aeruginosus*	1,000 m
Red Kite *Milvus milvus*	1,500 m (4,000 m)
Black Kite *Milvus migrans*	1,000 m (3,000 m)
White-tailed Eagle *Haliaeetus albicilla*	3,000 m (6,000 m)
Hobby *Falco subbuteo*	500 m (3,000 m)
Peregrine *Falco peregrinus*	1,000 m; tree breeders population 3,000 m – *Brutpaare der Baumbrüterpopulation 3.000 m*
Crane *Grus grus*	500 m
Corncrake *Crex crex*	500 m around regular breeding sites; density hotspots should be considered irrespective of the current location of breeding sites. – *500 m um regelmäßige Brutvorkommen; Dichtezentren sollten insgesamt unabhängig von der Lage der aktuellen Brutplätze berücksichtigt werden.*
Great Bustard *Otis tarda*	3,000 m around breeding areas; wintering ranges; all corridors between areas of occurrence should be kept free. – *3.000 m um die Brutgebiete; Wintereinstandsgebiete; Freihalten aller Korridore zwischen den Vorkommensgebieten.*
Golden Plover *Pluvialis apricaria*	1,000 m (6,000 m)
Woodcock *Scolopax rusticola*	500 m around display territories; density hotspots should be considered irrespective of the current location of breeding sites. – *500 m um Balzreviere; Dichtezentren sollten insgesamt unabhängig von der Lage der aktuellen Brutplätze berücksichtigt werden.*
Eagle Owl *Bubo bubo*	1,000 m (3,000 m)
Short-eared Owl *Asio flammeus*	1,000 m (3,000 m)
Nightjar *Caprimulgus europaeus*	500 m around regular breeding sites – *500 m um regelmäßige Brutvorkommen*
Hoopoe *Upupa epops*	1,000 m (1,500 m) around regular breeding sites – *1.000 m (1.500 m) um regelmäßige Brutvorkommen*
Endangered meadow bird species sensitive to disturbance: Snipe *Gallinago gallinago*, Black-tailed Godwit *Limosa limosa*, Redshank *Tringa totanus*, Curlew *Numenius arquata* and Lapwing *Vanellus vanellus*	500 m (1,000 m); in case of the Lapwing this also applies to regular breeding sites in arable land, when at least of regional importance. – *500 m (1.000 m); gilt beim Kiebitz auch für regelmäßige Brutvorkommen in Ackerlandschaften, soweit sie mindestens von regionaler Bedeutung sind.*
Colony breeders – *Koloniebrüter*: Herons – *Reiher* Gulls – *Möwen* Terns – *Seeschwalben*	1,000 m (3,000 m) 1,000 m (3,000 m) 1,000 m (min. 3,000 m)

Table 2: Selection of CLC classes to define breeding season habitat (used for breeding and foraging during the breeding season) for a selection of bird species sensitive to wind turbines. "X" indicates "no breeding season habitat", "0" indicates "breeding season habitat". – *Auswahl der CLC Landnutzungsklassen zur Eingrenzung des Brutzeitlebensraums (Bruthabitat und während der Brutzeit aufgesuchte Nahrungshabitate) für einige windkraftsensible Beispielarten. „X" steht für „kein Brutzeitlebensraum", „0" steht für „Brutzeitlebensraum".*

CORINE Land Cover classes – *CORINE Landnutzungsklassen*		Black Stork – *Schwarzstorch*	Lesser Spotted Eagle – *Schreiadler*	Montagu's Harrier – *Wiesenweihe*	Red Kite – *Rotmilan*	Snipe – *Bekassine*	Lapwing – *Kiebitz*
Urban fabric	1.1.1 Continuous urban fabric – *Durchgängig städtische Prägung*	x	x	x	x	x	x
	1.1.2 Discontinuous urban fabric – *Nicht durchgängig städtische Prägung*	x	x	x	0	x	x
Industrial, comercial and transport units	1.2.1 Industrial or commercial units – *Industrie- und Gewerbeflächen*	x	x	x	0	x	0
	1.2.2 Road and rail networks and associated land – *Straßen, Eisenbahn*	x	x	x	0	x	x
	1.2.3 Port areas – *Hafengebiete*	x	x	0	0	x	x
	1.2.4 Airports – *Flughäfen*	x	x	0	0	x	0
Mine, dump and construction sites	1.3.1 Mineral extraction sites – *Abbauflächen*	x	x	0	0	x	0
	1.3.2 Dump sites – *Deponien und Abraumhalden*	x	x	0	0	x	0
	1.3.3 Construction sites – *Baustellen*	x	x	x	x	x	x
Artificial, non-agricultural vegetated areas	1.4.1 Green urban areas – *Städtische Grünflächen*	x	x	x	x	x	x
	1.4.2 Sport and leisure facilities – *Sport- und Freizeitanlagen*	x	x	x	0	x	x
Arable land	2.1.1 Non-irrigated arable land – *Nicht bewässertes Ackerland*	x	0	0	0	x	0
Permanent crops	2.2.1 Vineyards – *Weinanbauflächen*	x	x	x	0	x	x
	2.2.2 Fruit trees and berry plantations – *Obst- und Beerenobstbestände*	x	0	x	0	x	x
Pastures	2.3.1 Pastures – *Wiesen und Weiden*	0	0	0	0	0	0
Heterogeneous agricultural areas	2.4.2 Complex cultivation patterns – *Komplexe Parzellenstrukturen*	x	0	0	0	x	0
	2.4.3 Land principally occupied by agriculture, with significant areas of natural vegetation – *Landwirtschaft und natürliche Bodenbedeckung*	x	0	0	0	x	0
Forests	3.1.1 Broad-leaved forest – *Laubwälder*	0	0	x	0	x	x
	3.1.2 Coniferous forest – *Nadelwälder*	0	x	x	0	x	x
	3.1.3 Mixed forest – *Mischwälder*	0	0	x	0	x	x
Scrub and/or herbaceous vegetation associations	3.2.1 Natural grasslands – *Natürliches Grünland*	0	0	0	0	0	0
	3.2.2 Moors and heathland – *Heiden und Moorheiden*	0	0	0	0	0	0
	3.2.4 Transitional woodland-shrub – *Wald-Strauch-Übergangsstadien*	0	0	0	0	x	x
Open spaces with little or no vegetation	3.3.1 Beaches, dunes, sands – *Strände, Dünen und Sandflächen*	x	x	0	x	x	0
	3.3.2 Bare rocks – *Felsflächen ohne Vegetation*	x	x	x	x	x	x
	3.3.3 Sparsely vegetated areas – *Flächen mit spärlicher Vegetation*	x	0	0	0	x	0
	3.3.4 Burnt areas – *Brandflächen*	x	0	x	0	x	x
	3.3.5 Glaciers and perpetual snow – *Gletscher und Dauerschneegebiete*	x	x	x	x	x	x
Inland wetlands	4.1.1 Inland marshes – *Sümpfe*	0	0	0	x	0	0
	4.1.2 Peat bogs – *Torfmoore*	0	0	0	0	0	0
Maritime wetlands	4.2.1 Salt marshes – *Salzwiesen*	x	x	0	x	0	0
	4.2.3 Intertidal flats – *In der Gezeitenzone liegende Flächen*	x	x	x	x	x	0
Inland waters	5.1.1 Water courses – *Gewässerläufe*	0	x	x	0	x	x
	5.1.2 Water bodies – *Wasserflächen*	x	x	x	x	x	x
Marine waters	5.2.1 Coastal lagoons – *Lagunen*	x	x	0	x	0	0
	5.2.2 Estuaries – *Mündungsgebiete*	x	x	x	x	x	x
	5.2.3 Sea and ocean – *Meere und Ozeane*	x	x	x	x	x	x

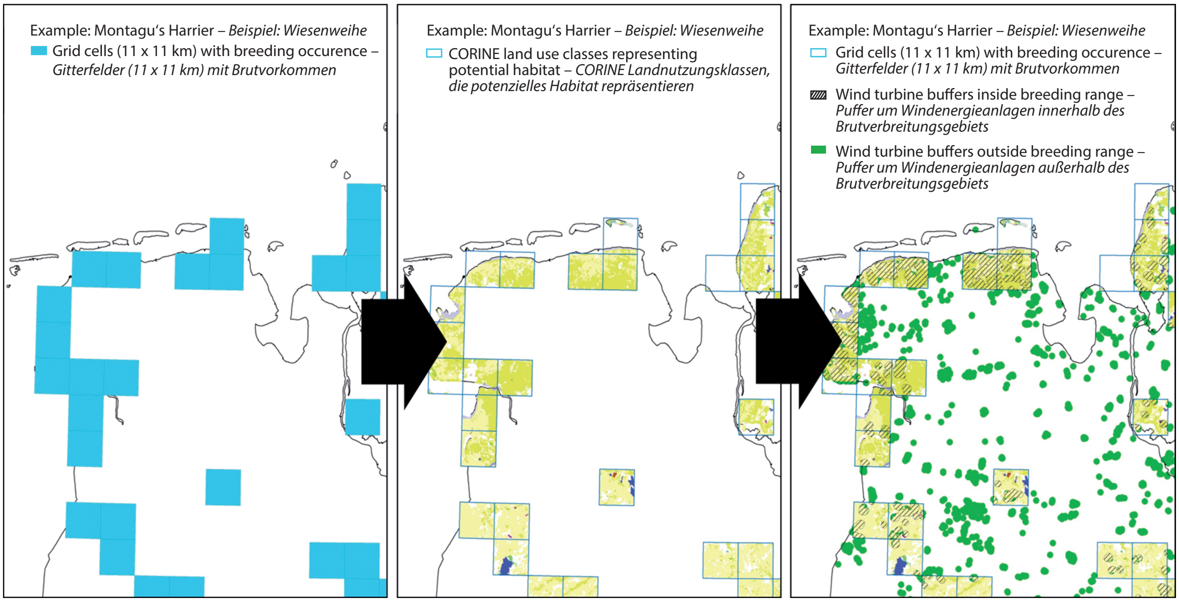


Fig. 1: Illustration of methodological approach: Within grid cells with breeding occurrence (left map) CLC classes representing potential habitat were identified (central map) and overlaid with wind farm locations buffered by the LAG VSW distance recommendation (right maps). – *Veranschaulichung des methodischen Ansatzes: Innerhalb der Gitterfelder mit Brutzeitvorkommen (linke Karte) wurden CLC Landnutzungsklassen identifiziert, die potenzielles Habitat darstellen (mittlere Karte), und dieses mit den, entsprechend der LAG VSW Empfehlungen, gepufferten Windkraftstandorten überlagert (rechte Karte).*

classes defined in Gedeon *et al.* (2014) for each grid cell and sensitive species and multiplied the grid cell specific population estimate by the percentage potential breeding season habitat identified to be disturbed by wind turbines (i.e. overlaid by a species-specific buffer based on the LAG VSW (2014) distance recommendations). Grid cell specific population estimates identified to potentially be affected by wind farm related risks were summed and compared with the national population estimates (sum of geometric means of abundance classes of all grid cells).

2.4 Testing for correlation

Based on a generated gridded dataset of wind turbine locations and presence/absence as well as abundance information of Gedeon *et al.* (2014) at the same spatial resolution, it was possible to test for correlations between the observed frequency of wind turbines and 1) the number of sensitive bird species per grid cell and 2) the mean number of breeding pairs of all sensitive species assessed per grid cell. As statistical tests concluded that the correlated characteristics are not normally distributed, we used a non-parametric Spearman's rank correlation.

3. Results

The assessment resulted in maps visualizing the degree of potential habitat disturbance due to wind turbines for individual species as well as overview maps indicating the distribution of overall habitat disturbance potential across species. Moreover, it was possible to estimate the proportions of populations of sensitive species potentially affected.

3.1 Species-specific maps

Species-specific maps visualizing the degree of potential habitat disturbance due to wind turbines (see Fig. 2) were generated for all 30 sensitive species assessed. For each grid cell with breeding occurrence the percentage overlap between habitat and wind farm risk areas can be read from those maps, allowing local assessments of existing potential pressures on sensitive species while providing a national overview at the same time. The maps represent a valuable tool for species conservation because they enable a quick overview of the regional strength of pressures from wind energy generation and make it easy to assess and compare pressures e.g. across different population strongholds or e.g. between Special Protection Areas (SPAs) and their surrounding respectively other regions.

Results can be best explained looking at an example species. Fig. 2 presents the species-specific map for Montagu's Harrier *Circus pygargus*. For this species highest overlaps between habitat and wind farm risk areas occur in grid cells bordering the North Sea coast of Lower Saxony and Schleswig-Holstein. Here, regularly more than 50 % (and up to 78 %) of potentially suitable habitat is disturbed by wind farm related risks. Besides collision risk (Langgemach & Dürr 2016) also displacement of Montagu's Harrier has been proven for particular subpopulations (Joest *et al.* 2013, LAG VSW 2014). Looking at population strongholds in Germany (in case of Montagu's Harrier regions in which several bordering grid cells support abundances

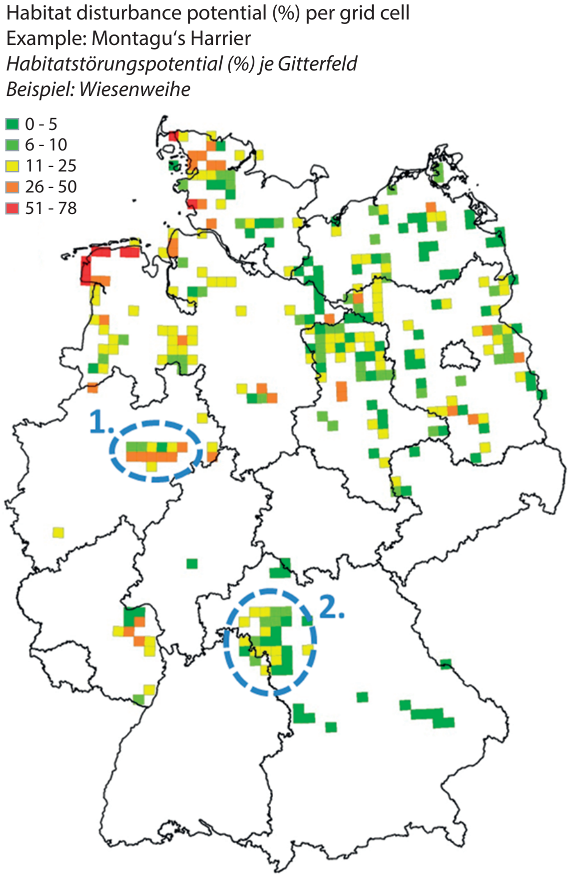


Fig. 2: Percentage overlap between potential Montagu's Harrier breeding season habitat and wind farm related risks in grid cells with breeding occurrence according to Gedeon *et al.* (2014). Circle 1 (Hellwegbörde, North Rhine-Westphalia) and circle 2 (Mainfranken, Bavaria) represent the two German population strongholds with comparably high abundances, respectively. – *Prozentuale Überlappung zwischen potenziellem Brutzeithabitat der Wiesenweihe und windkraftinduzierten Risiken innerhalb von Gitterfeldern mit Brutvorkommen nach* Gedeon et al. *(2014). Markierung 1 (Hellwegbörde, Nordrhein-Westfalen) und Markierung 2 (Mainfranken, Bayern) repräsentieren die beiden deutschen Vorkommensschwerpunkte der Art mit jeweils vergleichsweise hohen Bestandsdichten.*

of 8-20 pairs according to Gedeon *et al.* (2014)) interesting differences can be detected. Besides the coastal grid cells supporting breeding Montagu's Harriers, the 'Hellwegbörde' (see Fig. 2), one of two key regions for the species in Germany, represents the region with the highest percentage of potential habitat disturbance for the species. For half of the grid cells supporting this local population stronghold 26-50 % of potentially suitable habitat is overlaid with wind farm risk areas and also other grid cells of this hotspot are strongly disturbed. The second population stronghold 'Mainfranken', so far, is less influenced by wind turbines. Nonetheless, also in this region several grid cells indicate potential habitat disturbance between 11-25 %. Considering the request formulated by LAG VSW (2014) to secure sufficiently large wind farm free zones to preserve source populations, further development of wind turbines especially within the population strongholds already strongly affected has to be questioned.

3.2 Potential habitat and population level disturbance at national scale

To get a general overview and compare the relative strength of wind farm related risks sensitive species are currently facing in Germany, national figures for percentage potential habitat disturbance have been calculated (see Table 3). The analysis identified a considerable habitat disturbance potential for particular species and subsets of sensitive species respectively. By combining the results on percentage habitat disturbance obtained with abundance data available at grid cell scale (geometric means of abundance classes of Gedeon *et al.* (2014)) is was possible to estimate the proportion (%) of the German population likely to be affected by wind farm related risks.

For most species values derived for potential habitat disturbance and proportion of the population influenced by wind energy were relatively similar. As expected, correlations between both figures occurred especially in relatively equally distributed species, inhabiting comparably large territories (e.g. Black Kite *Milvus migrans*, Eagle Owl *Bubo bubo*, Hobby *Falco Subbuteo*, Montagu's Harrier, Red Kite *Milvus milvus* etc.). For some species with comparably small territories considerable differences between habitat and population level effect were detected (e.g. Lapwing *Vanellus vanellus*). Here effects at population level were higher than one would expect looking only at the percentage overlap between wind turbine buffers and potential breeding season habitat, indicating a concentration of the respective population within areas of increased wind energy generation.

Moreover, for species with very small ranges and/or very small populations considerable differences between potential habitat and population level effects were found (e.g. Golden Plover *Pluvialis apricaria*, Great Bustard *Otis tarda*, Hen Harrier *Circus cyaneus*, Hoopoe *Upupa epops*). Those results should be treated with caution and are likely to be a consequence of the chosen methodology (grid cells of approx. 11 x 11 km) not being applicable to identify potential effects at such fine scale.

To support the assessment of the potential effects identified it can be helpful to consider the results in light of the proportions of sensitive species occurring within SPAs (Wahl *et al.* 2015) (see Table 3). For certain species this clearly facilitates the assessment of wind farm related risks. For example, for some species of grouse one may conclude that the current state of

Table 3: Overview on species-specific potential percentage habitat disturbance due to wind turbines applying the LAG VSW distance recommendations; the percentage population of the respective sensitive species likely to be affected by wind farm related risks; to assess the disturbance potentials identified percentage populations occurring within designated SPAs as well as species-specific distance recommendations are presented. – *Übersicht zur potenziellen prozentualen Störung von Habitaten durch Windkraftanalagen unter Anwendung der LAG VSW Abstandsempfehlungen, sowie beeinflusste Populationsanteile als sensitive eingestuften Arten; zur besseren Einordnung und Bewertung der identifizierten Störungspotenzials werden zudem der jeweilige Populationsanteil innerhalb von EU-Vogelschutzgebieten, sowie die geltenden Abstandsempfehlungen dargestellt.*

Species – *Art*	Habitat disturbance potential (%) – *Habitatstörungs-potenzial (%)*	Population potentially influenced by wind energy (%) – *Potenziell beeinflusster Populationsanteil (%)*	Population occurring within SPAs (%) – *Populationsanteil innerhalb von EU Vogelschutzgebieten (%)*	Species-specific distance recommendation – *artspezifische Abstandsempfehlung*
Black Grouse – *Birkhuhn*	0.0	0.0	63.1	1,000 m
Black Kite – *Schwarzmilan*	5.0	4.6	28.3	1,000 m
Black Stork – *Schwarzstorch*	19.1	20.4	29.0	3,000 m
Black-tailed Godwit – *Uferschnepfe*	3.9	4.6	79.2	500 m
Capercaillie – *Auerhuhn*	0.9	0.3	61.5	1,000 m
Corncrake – *Wachtelkönig*	3.4	2.8	58.8	500 m
Crane – *Kranich*	3.3	2.6	41.4	500 m
Curlew – *Großer Brachvogel*	4.1	4.5	40.2	500 m
Eagle Owl – *Uhu*	5.3	5.5	18.6	1,000 m
Golden Eagle – *Steinadler*	1.0	0.7	73.1	3,000 m
Golden Plover – *Goldregenpfeifer*	7.9	12.0	100.0	1,000 m
Great Bustard – *Großtrappe*	18.0	6.0	100.0	3,000 m
Hazel Grouse – *Haselhuhn*	2.1	1.0	58.2	1,000 m
Hen Harrier – *Kornweihe*	11.7	5.4	95.4	1,000 m
Hobby – *Baumfalke*	2.3	2.2	n.a.	500 m
Honey-buzzard – *Wespenbussard*	3.0	3.1	25.1	1,000 m
Hoopoe – *Wiedehopf*	7.5	5.3	55.7	1,000 m
Lapwing – *Kiebitz*	3.6	5.9	24.5	500 m
Lesser Spotted Eagle – *Schreiadler*	54.6	49.7	82.3	6,000 m
Marsh Harrier – *Rohrweihe*	9.1	8.9	27.8	1,000 m
Montagu's Harrier – *Wiesenweihe*	13.0	14.4	50.2	1,000 m
Nightjar – *Ziegenmelker*	0.9	1.2	55.6	500 m
Peregrine – *Wanderfalke*	3.6	3.0	40.8	1,000 m
Ptarmigan – *Alpenschneehuhn*	0.0	0.0	87.3	1,000 m
Red Kite – *Rotmilan*	9.3	9.8	18.6	1,500 m
Redshank – *Rotschenkel*	3.4	4.1	74.0	500 m
Short-eared Owl – *Sumpfohreule*	13.9	13.6	100.0	1,000 m
Snipe – *Bekassine*	2.1	1.4	48.9	500 m
White Stork – *Weißstorch*	7.1	6.5	34.4	1,000 m
Woodcock – *Waldschnepfe*	0.7	0.9	n.a.	500 m

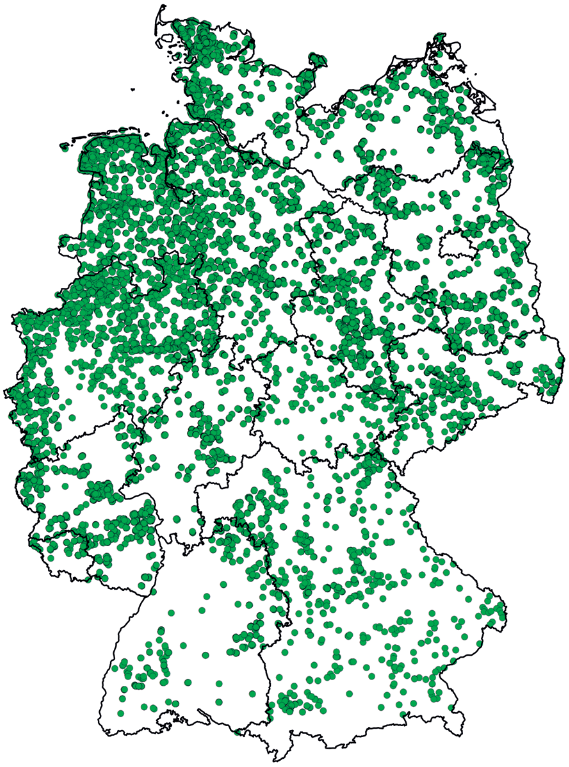
wind farm development does not represent a considerable threat, e.g. 61.5 % of the German Capercaillie *Tetrao urogallus* population occur within designated SPAs and only a fraction of the national population (0.3 %) was estimated to may potentially be affected by habitat disturbance potentials associated with wind energy. In terms of a species such as Black Stork *Ciconia nigra* the situation is entirely different. While only 29 % of the national population benefits from the protection offered by SPAs, a similar proportion of the population (20.4 %) was assessed to face wind farm related risks within its breeding season habitat. In this context it is important to mention that SPAs do not represent wind farm free zones. Nonetheless, one would expect that bird conservation needs have a higher priority within wind farm approval processes deciding about the construction of wind turbines within SPAs designated to support populations of wind farm sensitive species.

3.3 Distribution of wind farm related risks across species

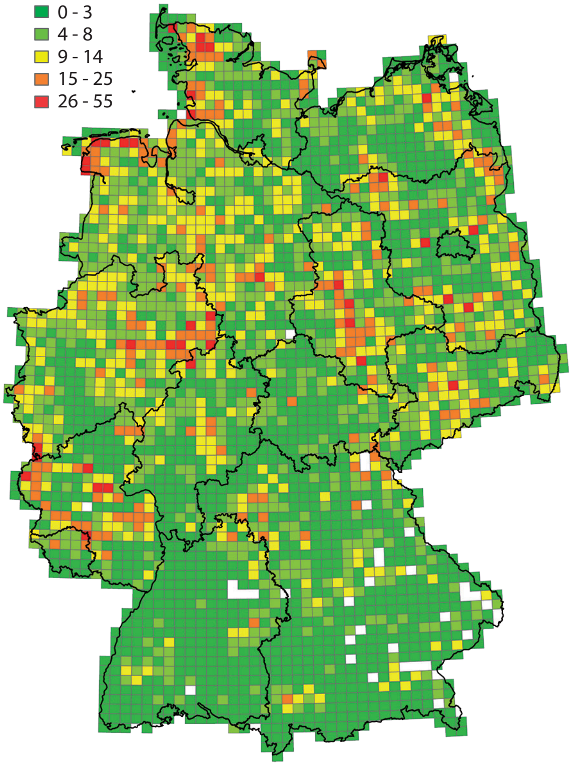
Moreover, the results derived at species level were combined across all species analysed by calculating a mean percentage habitat disturbance value based on the species-specific figures per grid cell (irrespective of the total species-specific habitat extent per grid cell). The resulting map identified the distribution and potential strength of habitat disturbance effects considering the assemblage of wind farm sensitive species (see Fig. 3, B & C). Clearly, the general distribution of habitat disturbance potential is predefined by wind turbine frequency (see Fig. 3, A; due to map resolution single turbine locations are sometimes indistinguishable). Nonetheless, regions with increased conflict potential between bird conservation and the wind industry, mainly as a result of a high diversity of impacted species in particular

Fig. 3: A: Distribution of operational wind turbines across Germany, status 2015. **B**: Mean percentage habitat disturbance across the 30 sensitive species assessed per grid cell. **C**: Summed spatial habitat disturbance potential (km²) across the 30 sensitive species assessed per grid cell. – **A**: *Standorte operative Windkraftanlagen in Deutschland, Stand 2015.* **B**: *Prozentuale Habitatstörung, gemittelt über die 30 untersuchten sensitiven Vogelarten je Gitterfeld.* **C**: *Summe des potenziell gestörten Habitats (km²) über die 30 untersuchten sensitiven Vogelarten je Gitterfeld.*

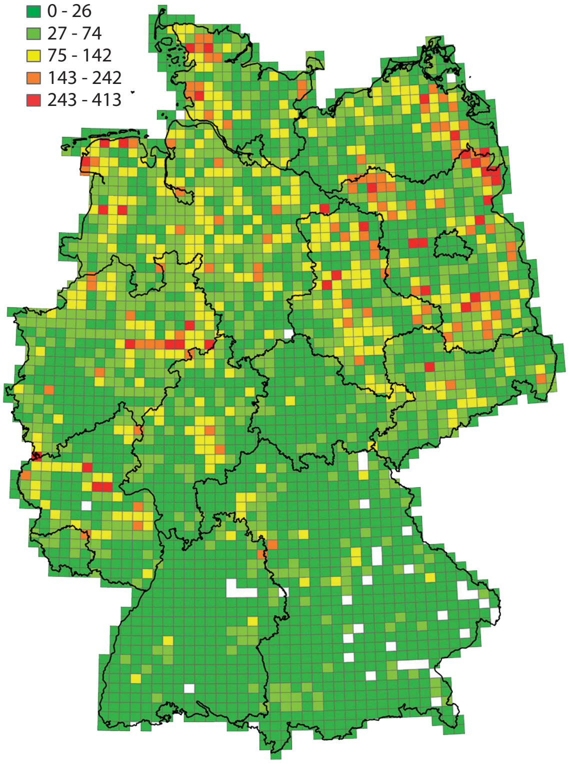
A ● Locations of operational wind turbines in Germany – *Windkraftanlagenstandorte in Deutschland*



B Mean habitat disturbance potential (%) – *Mittleres Habitatstörungpotenzial (%)*



C Summed habitat disturbance potential (km²) of all species assessed – *Summe der Habitatstörungspotenziale (km²) aller untersuchter Arten*



regions, were identified. Especially the North Sea coast and its hinterland, as well as the fertile and open 'Börde' landscapes in central Germany are strongest disturbed by wind farms. Moreover, strong interactions between sensitive species and wind turbines occur in the western low mountain ranges of Eifel and Hundsrück. Generally, the relative concentration of turbines in North Rhine-Westphalia and Lower Saxony is clearly visible on the mean habitat disturbance map (see Fig. 3, B).

To ensure the results obtained a second approach was tested, avoiding the calculation of a mean value per grid cell. This was done to assure that in cases where e.g. only a single species occurring in a grid cell faces large scale potential habitat disturbance while additional sensitive species only face small effects within the same grid cell, considerable effects on one species are not relativized by small or no effects on other species. In this second approach, the spatial extents (km^2) of the potentially disturbed breeding season habitats of all sensitive species occurring in a respective grid cell were summed (see Fig. 3, C). Both approaches to derive an overview map on the distribution and strengths of wind farm related pressures on the assemblage of wind farm sensitive species identified very similar patterns, considering that mean potential habitat disturbance (%) is compared with summed potentially disturbed habitat (km^2). Moreover, data were classified by natural breaks in GIS, a classification scheme that aims at grouping similar values and maximise differences between classes by dividing features into classes whose boundaries are set where relatively big differences in data values occur.

3.4 The case of Red Kite

For one species, the Red Kite, it was possible to attempt to validate the assessment methodology. A nationwide Red Kite survey carried out in 2011 and 2012 reported the spatially explicit location of 6,840 Red Kite nests across the species range within Germany (DDA, unpublished data). Gedeon *et al.* (2014) report a national population of 12,000 – 18,000 pairs (mean 15,000 pairs). Thus the control sample comprised about 45.6 % of the likely German nesting sites of Red Kite. Combining nesting locations and wind turbine locations in GIS and buffering the nest locations with the recommended 1,500 m concluded that 626 nesting locations, representing 9.15 % (626 / 6,840 * 100) of the recorded nesting sites of Red Kite, occurred within 1,500 m of operational wind turbines. In this context it is important to note that until publication of the current recommendations (LAG VSW 2014) a 1,000 m distance was recommended for Red Kite (LAG VSW 2007) and several federal states still make use of this superseded distance recommendation within approval processes.

High consistency among the results obtained using the different assessment approaches was achieved (see Table 4). All methods indicated that about 9 % of the species habitat and population face wind farm related risks based on the current state of wind energy usage in Germany.

3.5 Testing for correlations

In a further analysis step we tested for correlations between the observed frequency of wind turbines and the number, respectively diversity, of sensitive bird species per grid cell, and between wind turbine frequency and mean number of breeding pairs across all sensitive species per grid cell (using the geometric mean of the respective abundance classes published in Gedeon *et al.* (2014)). As this analysis did not require the consideration of CLC classes, also species excluded from the other assessments for methodological reasons (colony breeding heron, gull and tern species as well as

Table 4: Comparison of assessment results for potential influence of wind energy production on Red Kite. – *Vergleich der Ergebnisse zum Einflusspotenzial der Windenergieproduktion auf den Rotmilan.*

Method – ***Methode***	**Result** – ***Ergebnis***	**Description** – ***Beschreibung***
Potentially disturbed breeding season habitat in Germany – *Potenziell gestörtes Brutzeithabitat in Deutschland*	9.3 %	Definition of potential breeding season habitat using CORINE land use classes and calculating overlap with 1,500 m buffers around operational wind turbines – *Eingrenzung des potenziellen Brutzeithabitats über CORINE Landnutzungsklassen und Berechnung der Überlagerung mit 1.500 m Puffern um Windkraftstandorte*
Proportion of national population influenced – *Anteil der beeinflussten nationalen Population*	9.8 %	Multiplying % potential habitat disturbance with geometric mean of abundance class from Gedeon *et al.* (2014) at grid cell level and adding up those figures for entire Germany – *Multiplikation der potenziellen % Habitatstörung mit dem Geomittel der Abundanzklassen nach* Gedeon et al. *(2014) auf Ebene der Gitterfelder und Summierung dieser Werte für ganz Deutschland*
Nesting locations with operational wind turbine within 1,500 m distance – *Neststandorte mit Windkraftanlage innerhalb einer Distanz von 1.500 m*	9.2 %	Buffering of known nesting sites by the recommended 1,500 m exclusion zone and assessing overlap with operational turbines – *Pufferung der bekannten Neststandorte mit dem empfohlenen Mindestabstand von 1.500 m und Überprüfung der Überschneidung mit im Betreib befindlichen Windkraftanlagen*

Osprey, White-tailed Eagle, Bittern and Little Bittern) were included in this test for correlations. Obviously, species are defined to be sensitive to wind energy when they occur in or commute through areas where wind farms have been erected/built and behavioural observations or the discovery of collision victims proof an interaction with the turbines. Accordingly, a certain correlation between both parameters was expected.

We found highly significant though relatively week correlations between the investigated characteristics. Spearman's rank correlation identified a rho (Spearman's rank correlation coefficient) = 0.19 for wind turbine frequency and diversity of sensitive species and a rho = 0.22 for wind turbine frequency and the mean number of breeding pairs of sensitive species. The results indicate a high variance in the data. While the high significance of the correlations proofs a relationship between the correlated characteristics and indicates that areas with high turbine frequency can overlap with diversity hotspots respectively high breeding populations of sensitive species, there seems to be no general concentration of wind farms inside diversity and/or population hotspots when looking at the overall assemblage of sensitive species.

4. Discussion

The results indicate a strong overlap between wind farm related risks and the potential breeding season habitats of the majority of bird species identified to be sensitive to the operation of wind turbines in the vicinity of their breeding sites.

A few methodology-induced aspects, influencing the results obtained, need to be considered when interpreting e.g. the figures on percentage potential habitat disturbance. Species for which comparably big wind turbine free buffers are recommended regularly show considerable overlaps between breeding season habitat and wind farm related risks (e.g. Lesser-spotted Eagle *Clanga pomarina* (54.6 %), Black Stork (19.1 %) and Great Bustard (18.0 %)). The same applies to species with small distributional ranges in Germany (e.g. Golden Plover (7.9 %), Hen Harrier (11.7 %) and Short-eared Owl *Asio flammeus* (13.9 %)). Observed habitat disturbance potential is greatest when both aspects are combined, as can be observed in case of the Lesser-spotted Eagle. The species shows a restricted distribution in the North-East of Germany (Gedeon *et al.* 2014) and due to its high conservation concern and high vulnerability to both, collision with wind turbines and displacement from foraging habitat in vicinity of wind turbines (LAG VSW 2014), 6,000 m between breeding sites and wind turbines have been recommended as a spatial buffer. For Lesser-spotted Eagle the assessment concluded that more than half (54.6 %) of the species breeding season habitat is overlaid by wind farm related risks.

Moreover, there is a group of comparably widespread species with medium-sized recommended wind turbine exclusion zones between 1,000-1,500 m (Marsh Harrier *Circus aeruginosus* (9.1 %), Montagu's Harrier (13.0 %), Red Kite (9.3 %) and White Stork *Ciconia ciconia* (7.1 %)) that also face the potential disturbance of considerable proportions of their breeding season habitats. Interestingly, this group exclusively comprises species foraging mainly in open landscapes. The strong interaction indicates an extensive spatial influence of wind energy generation as widespread species appear to be affected across their distributional ranges. The fact that especially Montagu's Harrier and Red Kite show effects of a very similar strength in terms of habitat and population level disturbance (see Table 3) indicates a less clumped distribution of these species. Their comparably large territories prevent the occurrence of very high densities achieved by species with small territories and leads to a comparably even spread of individuals across the distributional range. In consequence, the estimated figures for habitat and population level disturbance are relatively similar.

Also the group of meadow-breeding waders should be mentioned (Black-tailed Godwit *Limosa limosa* (3.9 %), Curlew *Numenius arquata* (4.1 %), Lapwing (3.6 %), Redshank *Tringa totanus* (3.4 %) and Snipe *Gallinago gallinago* (2.1 %)). Considering the small recommended exclusion zones of 500 m, the potential disturbances of 2 to 4 % of the breeding season habitat indicates that wind energy imposes a pressure on this species group. Several meadow-breeding wader species showed considerable breeding range reductions in Germany during the period 1985-2009. A 21-50 % breeding range loss is recorded for Black-tailed Godwit, Curlew and Snipe (DDA, unpublished data). In this context the identified overlap between wind farm related risks and potential breeding season habitat indicates a relevant additional pressure on the remaining potential habitats of these species. Moreover, the comparably high habitat specialization of several meadow breeding waders has to be taken into account when assessing the results obtained. Due to specialization on wet open habitats comparably few CLC classes are defined to represent potential breeding season habitat. For example arable land, covering about 33 % of the overall German territory (BMEL 2014), has not been considered to represent potential breeding season habitat for Black-tailed Godwit, Redshank and Snipe. For such more specialized species for which comparably small potential breeding season habitat was identified the disturbance of comparably small percentages of that habitat may have another effect than for species using a large variety of habitats, because for specialized species less alternative switchover habitats are available. Moreover, especially for Lapwing considerable differences between habitat disturbance potential (3.6 %) and the population percentage potentially influenced

(5.9 %) were identified, indicating a concentration of the Lapwing population within areas heavily use for wind energy generation.

While montane and forest species, so far, seem to be less affected by the current state of wind farm development, plans to foster the construction of wind turbines in forested areas may impose increasing risks on these species in the future. Forest breeding birds like the Black Stork, also using open habitats in the surrounding of woodlands for foraging, today already show considerable interaction with habitats overlaid with wind farm related risks.

The LAG VSW (2014) recommend minimum distances of wind turbines to breeding sites of sensitive bird species, while the presented assessment used those distances to buffer wind turbines locations rather than breeding sites as such data are lacking for nearly all species, except Red Kite, at national scale. Accordingly, the achievement of very similar results when assessing the proportion of the Red Kite population influenced by wind farm related risks with and without consideration of the nest locations known for nearly half of the German population indicates that the chosen approach, applying the recommended minimum distances from operational turbines rather than breeding sites, appears suitable.

It should be noted that we do not assess the strength of the wind farm related population level impacts that may arise as a consequence of the operation of wind turbines inside potential breeding season habitats. The present study only indicates the likely proportion of potential breeding season habitat, as well as the proportion of the national population of sensitive species, that is likely to be disturbed by the current state of wind energy development in Germany. For impact assessments, especially at population level, a whole range of detailed species- and region-specific information would be required (species- and region-specific collision rates and/or displacement distances, exact nesting locations, data on mortality rates and recruitment etc.) that are currently not available. Nonetheless, our assessment for the first time estimates the spatial overlap between the habitats of sensitive species and wind farm related risks at the German national scale, helping to better understand the spatial implications of the current state of onshore wind farm development.

5. Conclusions

The findings of our study indicate a strong overlap between wind farm related risks, such as collision risk and displacement, and the potential breeding season habitats of the majority of bird species identified to be sensitive to the operation of wind turbines in the vicinity of their breeding sites. Montane and forest species seem least and open landscape species most affected by the wind farm development stage documented for the year 2015 in Germany. The spatial extent of bird habitats potentially disturbed and/or devaluated by onshore wind turbines is, at least for particular species, alarming and more detailed studies of particular subpopulations are required to quantify the population level impacts of the spatial risks identified in this study.

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The wind turbine locations used in frame of our assessment are based on data from the land use planning register of the federal state of Saxony-Anhalt with approval from the Ministry for Land Development and Transport, approval no.: MLV44/037/15. Moreover, data were provided with kind approval from the competent authorities of the other German federal states.

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6. Zusammenfassung

Busch, M., S. Trautmann & B. Gerlach 2017: Überlappung zwischen Brutzeithabitat und Windkraftrisiken: Ein räumlicher Ansatz. Vogelwelt 137: 169–180.

Während die Interaktionen zwischen Windenergieanlagen (WEA) und Vögeln in den vergangenen Jahren in vielfältiger Weise untersucht wurden, gibt es nur wenige großflächige Untersuchungen zu den möglichen Auswirkungen des bereits realisierten Ausbaustands des Windenergiesektors auf windkraftsensitive Arten. Um die von WEA ausgehenden Risiken für Vögel abzuschwächen, wurden in Deutschland durch die Länderarbeitsgemeinschaft der Vogelwarten (LAG VSW) Abstandsempfehlungen für WEA zu bedeutenden Vogellebensräumen sowie Brutplätzen ausgewählter, windkraftsensitiver Vogelarten definiert. Diese Abstandsempfehlungen wurden genutzt, um basierend auf dem aktuellen Ausbaustand der Windenergienutzung die Überlagerung von Brutzeitlebensräumen mit windkraftinduzierten Risiken als auch die potenziell beeinflussten Populationsanteile windkraftsensitiver Arten abzuschätzen. Die hier vorgestellte Untersuchung basiert auf Verbreitungs- und Häufigkeitsinformationen des aktuellen Atlas Deutscher Brutvogelarten (ADEBAR), Landnutzungsinformationen der Corine Land Cover Datenbank sowie Standortdaten zu im Betrieb befindlichen onshore WEA in Deutschland. WEA-Standorte in Gebieten mit Brutvorkommen windkraftsensitiver Arten wurden mit den artspezifischen Abstandsempfehlungen gepuffert und so die Überlappung mit potenziellen Brutzeit-

lebensräumen, die durch ihre Zugehörigkeit zu bestimmten Landnutzungsklassen identifiziert wurden, berechnet. Die Ergebnisse zeigen für die verschiedenen als windkraftsensitiv eingestufte Arten eine erhebliche Überlappung zwischen Brutzeitlebensräumen und Bereichen, in denen potenziell windkraftinduzierte Risiken auf diese Vogelarten einwirken. Insbesondere die Gruppe der Offenlandarten scheint vergleichsweise stark betroffen. Das identifizierte Habitatstörungspotenzial liegt hier regelmäßig bei Werten zwischen 9 und 13 % des Brutzeitlebensraums. Für einzelne Arten, oft mit nur kleinräumiger Verbreitung in Deutschland, werden darüber hinaus aber auch erheblich höhere Werte von bis zu 55 % des Brutzeithabitats im Einflussbereich von WEA erreicht. Für die meisten untersuchten Arten waren die Werte zur möglichen prozentualen Habitatstörung bzw. -beeinflussung und Schätzungen der durch WEA beeinflussten Populationsanteile recht ähnlich. Eine Validierung der angewandten Methode war zudem durch die Ergebnisse einer bundesweiten Rotmilankartierung 2011/12 möglich. Die Pufferung der in diesem Rahmen zusammengetragenen Neststandorte mit der artspezifischen Abstandsempfehlung erzielte im Hinblick auf das identifizierte Beeinflussungspotenzial eine gute Übereinstimmung mit den Ergebnissen die auf der Pufferung des WEA-Standorte basierten. Demnach scheint sich das räumliche Beeinflussungspotenzial von WEA auf Vogellebensräume auch ohne Brutplatzdaten, die zumeist nicht flächig vorliegen, recht gut abschätzen zu lassen.

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Population declines in eastern Palaearctic passerines

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Heim, W. 2017: Population declines in eastern Palaearctic passerines. Vogelwelt 137: 181–183.
Recent studies found that many migratory songbird species on the East Asian flyway are declining rapidly. Especially *Emberiza* bunting species seem to be highly vulnerable. Based on standardized bird ringing, declines were also found for bunting species at Muraviovka Park in Far East Russia. The reasons for these observed population changes are poorly understood, but trapping and land use changes are the most likely drivers. Point-stop-counts and a colour-ring study to learn more about survival and breeding success were initiated to get a better understanding of the potential causes. An international monitoring scheme is urgently needed for eastern Palaearctic landbirds.

Keywords: East Asian-Australasian flyway, landbirds, *Emberiza*, bird ringing

1. Introduction

The East Asian flyway is the least studied migration route and holds the highest number of globally threatened migratory species. This is especially true for songbirds: 254 passerines occur along the flyway, of which 170 are long-distance migrants, and 15 are listed as threatened on the IUCN Red List (Yong *et al.* 2015). In comparison, there is only one threatened migratory songbird species in the Eurasian-African flyway system (Aquatic Warbler *Acrocephalus paludicola*). Unlike Europe, where standardized monitoring schemes are established since decades, no international agreements exist to date in East Asia. However, threats like land reclamation, deforestation and agricultural intensification caused large-scale habitat changes, which likely affect bird populations (e.g. Larson 2015, Yong *et al.* 2015). Another problem for songbirds in East Asia is bird trapping for food and pet bird trade (e.g. Gilbert *et al.* 2012). On top of that, the region is expected to suffer from rapid climate change causing instability in the monsoon regime (e.g. Turner & Annamalai 2012), which could lead to prolonged periods of drought in the North.

Recent studies have revealed large-scale declines in both resident and migratory species of songbirds. For example, 145 species found to be declining between 1997-1998 to 2012-2013 based on transect counts on the island of Hainan, South China (Xu *et al.* 2016). In North China, 24 out of 34 songbird species declined according to data collected at two bird ringing stations between 2002 and 2011 (Jiao *et al.* 2016). However, these studies describe only local population trends. A comparative analysis with time series from Fennoscandia, China and Japan showed that numbers of the Rustic Bunting *Emberiza rustica* decreased by 72-88 % during the past 30 years (Edenius *et al.* 2016). Range-wide declines were also found for the Yellow-breasted Bunting *Emberiza aureola* – once one of the most abundant species in Siberia. The range of this long-distance migrant contracted by 5000 km and the population decreased by 84-95 % between 1980 and 2013 (Kamp *et al.* 2015). However, available data was biased towards the western part of their range, whereas quantitative data from sparsely populated Eastern Russia is scarce.

2. Methods

In 2011, a bird ringing project was established at Muraviovka Park in Far East Russia (49° 55’ 08,27” N, 127° 40’ 19,93” E). The aim of the Amur Bird Project is to collect long-term data on population trends of eastern Palaearctic migrants (Heim & Smirenski 2013). Birds are trapped and ringed following standard protocols (Heim *et al.* 2012). The autumn season lasts from the beginning of August until the end of October. However, trapping started only in September during the first two years. Therefore early migrating species (i.e. occurring already in August in significant numbers) were excluded from the following analysis. The total length of the mist nets increased from 90 meters in 2011 to 144 meters since 2014. Numbers of trapped individuals were corrected for net length.

3. Results

More than 30,000 birds were ringed between 2011 and 2015. Several species appeared in declining numbers during these first five years. This is especially true for the four most common species of buntings ($n > 300$, Fig. 1). Significant declines were found for Pallas´s Reed Bunting *Emberiza pallasi* ($F_{1,3} = 6.55$, $R^2 = 0.69$, $p = 0.08$) and Rustic Bunting ($F_{1,3} = 10.05$, $R^2 = 0.77$, $p = 0.05$), while Black-faced Bunting *Emberiza spodocephala* ($F_{1,3} = 3.91$, $R^2 = 0.57$, $p = 0.14$) and Little Bunting *Emberiza pusilla* ($F_{1,3} = 3.05$, $R^2 = 0.50$, $p = 0.18$) showed no statistically significant trends.

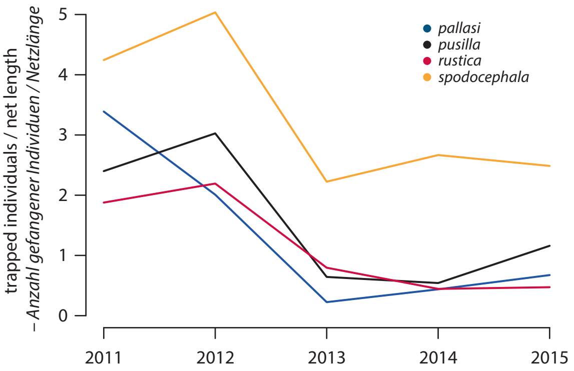

Fig. 1: Number of individuals trapped at Muraviovka Park during autumn seasons 2011–2015 for Pallas´s Reed Bunting *Emberiza pallasi,* Little Bunting *Emberiza pusilla*, Rustic Bunting *Emberiza rustica* and Black-faced Bunting *Emberiza spodocephala*. Total numbers are corrected for net length. – *Anzahl der durch die Beringungsstation "Muraviovka Park" auf dem Herbstzug 2011–2015 gefangenen Individuen der Pallasammer* Emberiza pallasi*, Zwergammer* Emberiza pusilla*, Waldammer* Emberiza rustica *und Maskenammer* Emberiza spodocephala.

4. Discussion

Two out of the four most common migratory *Emberiza* species were found to be declining at Muraviovka Park within the (rather short) observation period. This fits very well to the observed population changes mentioned above. The reasons for the dramatic declines of Eastern Palearctic Passerines are poorly understood. Climate change is believed to be the major driver for the declines found in North China (Jiao *et al.* 2016), while deforestation might be responsible for the changes in South China (Xu *et al.* 2016). Considering the Yellow-breasted Bunting, large-scale trapping is blamed (Kamp *et al.* 2015), while a combination of all these factors might have contributed to the decline of the Rustic Bunting (Edenius *et al.* 2016).

5. Outlook

To monitor the local breeding population of the endangered Yellow-breasted Bunting, point-stop counts at 75 points with a distance of 500 metres are conducted at Muraviovka Park three times during breeding season since 2015. First results suggest a strong negative effect of spring fires on abundance. A colour-ring study was started in 2015 to gather information about adult and juvenile survival and to shed light on the reasons for the demise of this species. Three out of seven males returned in 2016 to their territories. Breeding success is surveyed with miniature temperature loggers, allowing us to monitor the broods without having to disturb them after placement of the device. So far only few nests were found in 2016, but the work will be continued in 2017. To make the results comparable, four sympatric bunting species occurring in the same habitats were included in the study on survival and breeding success – Black-faced Bunting, Chestnut-eared Bunting *Emberia fucata*, Common Reed Bunting *Emberiza schoeniclus* and Japanese Reed Bunting *Emberiza yessoensis*. A total of almost 200 buntings were marked with individual colour-ring combinations in 2016.

Tracking studies using light-level geolocators could assist to gain a better understanding of songbirds and their spatial occurrence along the East Asian flyway during both breeding and non-breeding season (cf. Yamaura *et al.* 2016), and the use of stable isotope analysis might reveal new insights regarding migratory connectivity.

A broad-scale cross-boundary monitoring scheme is urgently needed to survey songbird populations in East Asia, since many species are heading for extinction, while major species-specific threats have not been identified yet. Also, first international agreements have been established and species action plans for Yellow-breasted Bunting and Rustic Bunting are on their way.

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6. Zusammenfassung:

Heim, W. 2017: Populationsabnahmen bei ostpaläarktischen Singvogelarten. Vogelwelt 137: 181–183.

Aktuelle Studien belegen, dass eine Vielzahl ziehenden Singvogelarten des Ostasiatischen Zugwegs schnell in ihren Beständen abnehmen. Insbesondere Ammern der Gattung *Emberiza* scheinen stark gefährdet zu sein. Abnahmen verschiedener Ammerarten wurden auch im Rahmen standardisierter Beringungsarbeiten im Muraviovka Park, einem geschützten Feuchtgebiet in der Amurregion des östlichen Russlands, festgestellt. Die Gründe für die beobachteten Populationsänderungen sind bisher wenig erforscht und kaum verstanden, aber der Vogelfang und Landnutzungsänderungen erscheinen als wahrscheinlichste Einflussfaktoren. Punkt-Stopp-Zählungen und eine Farbberingungsstudie, zur Untersuchung von Überlebensraten und Bruterfolg, wurden eingeleitet um ein besseres Verständnis möglicher Ursachen zu generieren. Ein internationales Monitoringprogramm für terrestrische ostpaläarktische Vogelarten ist dringend erforderlich.

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Modelling the potential distribution of Caucasian Grouse *Lyrurus mlokosiewiczi* breeding display habitat in Iran

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Habibzadeh, N. 2017: Modelling the potential distribution of Caucasian Grouse *Lyrurus mlokosiewiczi* breeding display habitat in Iran. Vogelwelt 137: 184–193.

Protecting and monitoring as many Caucasian Grouse leks as possible is very important for the better management of this species which is endemic to the Caucasus. Therefore, the identification of suitable habitats is essential. The goal of this study was to explore the potential distribution of Caucasian Grouse by a species distribution modelling approach for the Arasbaran region. The species distribution modelling was based on five different modelling techniques which are finally summarised in an ensemble forecasting approach. We considered six environmental descriptors (land cover and topographic features) which were extracted on 70 hectare spatial extent (472 m radii circle). Unsurprisingly, our models confirmed that altitude and slope were the primary influences on grouse distribution in the region. Additionally, lek occurrence was more likely in areas characterized by higher percent cover of the mosaic of mixed deciduous forest (canopy closure ≥ 50 %) and grassland; and low to moderate percent cover of the mosaic of mixed deciduous forest (canopy closure < 50 %) and grassland. The predicted distribution map can be used to select priority areas for conservation and to specify additional survey locations of the species in areas, which so far have been less well sampled.

Key words: suitable habitat, predictive modelling, Caucasian Grouse *Lyrurus mlokosiewiczi*

1. Introduction

The Caucasian Grouse (CG) is the unique species of the family *Tetraonidae*, associated with subalpine and alpine zones of high mountains of the Caucasus and adjacent high mountain territories of Turkey and Iran. At present, it is the single representative of the family in this region (Potapov 2008). CG is endemic to the Greater and Lesser Caucasus mountains and categorized as Near Threatened on the IUCN Red List (Gavashelishvili & Javakhishvili 2010, IUCN 2014). Ranked among the planet's 34 most diverse and endangered hotspots (Mittermeier *et al.* 2004), the Caucasus Eco-region covers a total area of 580,000 km^2, extending over the entirety of Armenia, Azerbaijan and Georgia, part of the Russian Federation, north-eastern Turkey, and part of north-western Iran (Williams *et al.* 2006, Zazanashvili *et al.* 2007).

The CG has the smallest range of any grouse species (Baskaya 2003, Gavashelishvili & Javakhishvili 2010) and this range is highly fragmented (Gavashelishvili & Javakhishvili 2010). Of all the grouse species in the world, the CG has received the least attention in terms of research (Baskaya 2003). A few studies have investigated the lek habitat of the Caucasian grouse (Gottschalk *et al.* 2007, Gavashelishvili & Javakhishvili 2010). Habitat loss and transformation are thought to be the major threats to the species, with many of the subalpine meadows within its range being used for intensive grazing. In the gentler terrain of the Lesser Caucasus road construction and changes in land use provide relatively easy access for developers and hunters, contributing to increased habitat disturbance and degradation (Gavashelishvili & Javakhishvili 2010).

CG is a key habitat quality indicator and flagship species that can be used to monitor the effectiveness of conservation measures, generating support for conservation amongst the public and raising environmental awareness. The grouse also has economic value because it attracts foreign birdwatchers and this benefits local economies (Gavashelishvili & Javakhishvili 2010).

Iran supports the smallest fragment of the range, just to the south of Armenia (Gavashelishvili & Javakhishvili 2010). Scott (1976) confirmed CG for Iran. It is distributed within Arasbaran region in East Azerbaijan province. Turkish and Iranian CG populations inhabit the upper mountain forests, subalpine meadows and the alpine zone within an altitudinal distribution of 1,300–3,300 m a.s.l. (Baskaya 2003). In Iran, the sites used for breeding display by CG have a mean altitude of 2,132 m (Standard Error = 56.28 m) (Habibzadeh 2010).

Species distribution models (SDMs) are being used in nearly all branches of life and environmental sciences (Thuiller *et al.* 2009). SDM is a useful tool for estimating the potential for species to occur in areas not previously surveyed (Guisan & Thuiller 2005). Models can be highly useful for conservation (Rodríguez *et al.* 2007) because they can (1) direct biological surveys towards places where species are likely to be found (Raxworthy *et al.* 2003, Engler *et al.* 2004, Bourg *et al.* 2005), (2) provide a baseline for predicting a species' response to landscape alterations and/or climate change (Thuiller 2003, Araújo *et al.* 2006), and (3) identify high-priority sites for conservation (Araújo & Williams 2000, Ferrier *et al.* 2002, Loiselle *et al.* 2003, Wilson *et al.* 2005). Numerous species distribution modelling methods are available (Guisan & Zimmermann 2000, Guisan & Thuiller 2005, Hirzel & Le Lay 2008) and some methods have proven to be more effective under certain modelling conditions than others (Elith *et al.* 2006, Hernandez *et al.* 2006). Regression analyses have been broadly applied in ecology. However, one field where the use of modern regression approaches has proven particularly useful is the modelling of the spatial distribution of species and communities (Guisan & Zimmermann 2000, Scott *et al.* 2002). Examples that used regression analyses to predict the distribution of birds include Manel *et al.* (1999, 2000), Suárez-Seoane *et al.* (2002), Brotons *et al.* (2004), Elith *et al.* (2006) and Kahler & Cavalieri (2014).

All modelling techniques relate the observed distribution of a species to several environmental variables (Austin 2007, Elith & Leathwick 2009). Nevertheless, some authors (e.g. Elith & Graham 2009, Thuiller *et al.* 2009) have demonstrated large discrepancies between different techniques, thus making the choice of an appropriate approach even more difficult. The results of different models are not only dependent on the relationship between species occurrence and environmental conditions (linear or nonlinear) but also on the used dataset, i.e. information on presence and absence (Elith & Graham 2009). Accordingly, summarising different model types into a comprehensive forecasting approach reduces uncertainty of individual techniques (Araújo & New 2007).

Gavashelishvili & Javakhishvili (2010) have attempted to assess the range of CG in the whole species' range using different statistical models. They were, however, hampered by a lack of representative data, particularly at a fine scale, from the entire range of CG in north-western Iran and, anyway, it is useful continuously to up-date such assessments. Gottschalk *et al.* (2007) developed a grouse habitat model for Turkey by means of a generalised linear model (GLM) analysis which did not consider the importance of amount and type of forests for habitat suitability.

According to our knowledge, documented studies investigating CG in Iran include: Scott (1976), Masuod (2004), Masoud *et al.* (2006) and Habibzadeh *et al.* (2010, 2013). Habibzadeh *et al.* (2013) have quantified the habitat requirements for this species at the landscape scale (across the study area) by examining the habitat characteristics around leks. However, their studies did not cover the effects of class metrics (per patch or land cover type). Their research into CG habitat associations has shown that the species requires a mosaic of certain habitats/land cover type.

For CG, leks are an obvious focal point at the landscape scale because they can be surveyed relatively easy over large areas. So, we undertook a landscape analysis of CG distribution and habitat quality with the following objectives: 1) development of a robust statistical framework to predict CG distribution in Iran, and 2) characterisation of the environmental predictors and their importance in the models on CG recorded geographic extent.

2. Material and methods

2.1 Study area

We conducted our study in the north-western Iranian uplands, covering the Lesser Caucasus. It consisted of one major region, Arasbaran, which constitutes the southern stretches of the Caucasus (Transcaucasia) (Asef & Muradov 2012). The specific area is between 626000 mE to 661100 mE and 4282200 mN to 4305300 mN, UTM Zone 38, comprising 316.54 km (Fig 3). The topography of the area involves more rugged terrains with elevation ranging from 800 to 2800 meters above sea level. The woody plants of Arasbaran were studied by Djavanshir (1976). Ebrahimi (1995) carried out studies in this region and recognised several forest associations mainly formed by Oak *Quercus macranthera*, *Q. petraea*, Hornbeam *Carpinus betulus*, *C. orientalis*, Maple *Acer campestre*, *A. monspessulanum*, Elm *Ulmus glabra*, Wild Cherry *Prunus avium*, Ash *Fraxinus excelsior* and Juniper *Juniperus communis*, *J. foetidissima*, *J. excelsa*. The main forest associations are pure Oak *Quercetum*, pure Hornbeam *Carpinetum*, mixed Oak-Hornbeam *Querco-Carpinetum*, mixed broad-leaved and needle-leaved species. Alijanpour (1996) studied the quantitative and qualitative characteristics of the old stands at an experimental forest station. His results showed the portion of Hornbeam within the old stands is the highest (51 %), followed by Oak (37 %), Maple (7 %) and other species (5 %). The structure of young stands in the mountainous forest of Arasbaran has been investigated by Sagheb *et al.* (2001). Their results indicated that most mixed broad-leaved stands are coppice with standards character. In coppice form, each stump produced six stems on average with a mean height of 3.7 m. The ability to produce coppice sprouts was highest among individual Oak and Hornbeam trees. The proportion of species within the young stands was: Hornbeam (32 %), Oak (29 %), Maple (8 %), Wild Cherry (1 %) and other species (30 %). The structure of the study stands was mainly composed of two layers, with standards in the upper layer and coppice sprouts in the understory. Juniper stands showed a peculiar structure with trees arranged in clusters; these stands do not regenerate easily.

2.2 Data collection

To spatially precise confirm lek locations identified by Masoud (2004) and Habibzadeh *et al.* (2013) in East Azerbaijan province based on field observations and interviews of local people, we identified these leks using foot and roadside surveys in spring 2013 and 2014 mid-April to late May. Surveys began 0.5 hrs before sunrise and continued until 2.5 hrs after sunrise; evening surveys (2 hrs before sunset until sunset) were also used to identify general locations of leks, which were subsequently visited during the early morning survey period. Indices such as feathers, fecal matter and tracks as well as direct observations, were used to identify leks. We also utilized Google Earth to provide an indigenous person, familiar with the region and with broad experiences in CG field research, with a general overview on the region to identify potential locations of leks before conducting and starting field trips. The updated distribution area and lek locations (n = 22) of CG in East Azerbaijan province, Iran is presented in Fig 3. We defined a lek as a site where two or more males were documented displaying on multiple visits within a single year or over multiple years.

2.3 Natural environmental variables

We calculated the following variables to describe environmental conditions at the sampling sites according to their acknowledged relevance to the ecology and distribution of the species (Gavashelishvili & Javakhishvili 2010, Habibzadeh *et al.* 2010, 2013): land cover and topographic variables. For land cover data we used forest data (type and density) from the Forest-Range and Watershed Management Organization (FRWMO 2014). Other land cover types were assessed using aerial photos, SPOT5 images and field work. For our analysis, we generated 12 land use types and using Fragstats 4.2 (McGarigal *et al.* 2012) with exhaustive sampling strategies (moving window) and computed the following landscape metrics according to their acknowledged relevance to CG at a defined scale (472 m radii circle) (Habibzadeh *et al.* 2013): Class Area (CA) and Patch Richness (PR). We chose this specific landscape extent to follow the results of Habibzadeh *et al.* (2013) indicating that the landscape structure within the 500-m distance from lek points is most important for CG. Because we had no data on the home range size of males and females of CG during the breeding season, we used Eurasian Black Grouse *Lyrurus tetrix* home range size (Starling 1992) as a better-studied congener to determine the correct scale for our study rather than choosing an arbitrary scale. The species' point of view or perception is an important feature to be considered in order to better understand the ways in which species interact with the spatial arrangements of their environment (Seoane & Baudry 2002, Addicott *et al.* 1987). We considered the mosaic of deciduous forests and grasslands as main habitats, confirmed to be of primary importance for presence of CG leks (Masoud *et al.* 2006, Gavashelishvili & Javakhishvili 2010, Habibzadeh *et al.* 2010, 2013). Cover type heterogeneity is discussed to be a prerequisite for CG at landscape scale (Habibzadeh *et al.* 2013). We therefore used patch richness to reflect the number of different cover type classes.

Using the Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) (ASTER GLOBAL DEM, available at: https://lpdaac.usgs.gov), the three most important factors describing the topographic context were compiled: slope, aspect and elevation. Slope gradient was computed using the 4-cell method in DEM Surface Tools (Jenness 2013) and aspect was calculated using ArcGIS Spatial Analyst and then transformed using a cosine transform. To provide congruence between the scales at which we measured land cover and topographic variables, we resampled topographic variables to the pixel size of land cover grids (30× 30 m) and each layer was converted to the study's geographic projection and clipped to the general area where the species occurs.

Finally variable redundancy within environmental variables was checked by Pearson's rank correlation (r). If two variables were highly correlated ($r \geq 0.7$), one of them was excluded to avoid co-linearity. As a result, six land cover and topographic variables were produced as predictor variables at 30 meter resolution (Table 1).

2.4 Modelling techniques and ensemble forecasting

In order to develop a robust distribution model for CG we employed two concepts of simplicity and complexity. Simple models (e.g. global or statistical models) allowed us to extrapolate from the output of the distribution model in order to identify areas suitable for the CG beyond the field surveys (Merow *et al.* 2014). In parallel, using complex, machine learning methods, we sought a more accurate understanding of the determinants of the current distribution. Accordingly, this study compared the following five modelling techniques: (1) Generalised linear model (GLM) (McCullagh & Nelder 1989), performed with polynomial terms (Pont *et al.* 2005, Logez *et al.* 2012) using a step-wise procedure to select the most significant variables based on the Akaike information criterion (AIC) (Akaike 1974). (2) Generalised additive model (GAM) (Hastie & Tibshirani 1990), performed with automatically selected smooth splines as a non-parametric extension of GLM to capitalise on the strengths of GLM without requiring the problematic steps of postulating a specific parametric response function. As for GLM, a stepwise procedure using the AIC was used to select the most parsimonious model. (3) Generalised boosting models (GBM) (or boosting regression trees, BRT) (Friedman *et al.* 2000, Friedman 2001) are highly efficient at fitting data that are non-parametric (Ridgeway 1999). (4) Random forests (RF) (Breiman 2001) are a combination of tree predictors such that each tree depends on the values of a random vector sampled independently and with the same distribution for all trees in the forest. Random forests are actually a learning ensemble consisting of a bagging of unpruned decision tree learners with a randomized selection of features at each split. (5) Maximum entropy (MaxEnt; Phillips *et al.* 2006) is an effective tool for estimating a large number of parameters with a small sample size. It eliminates problems associated with data endogeneity and collinearity (Golan *et al.* 1997). Finally, all five modelling techniques were combined in an ensemble forecasting framework as recommended by Araújo & New (2007).

The BIOMOD (BIOdiversity MODelling) package (Thuiller 2003) was used within R software (R Development Core Team, 2014). These tools enabled the examination of methodological uncertainties and the maximization of predictive performance of the SDMs (Thuiller *et al.* 2009).

2.5 Model evaluation

Since all these models require data on locations from which the subject is absent, and false absences can decrease the reliability of prediction models (Chefaoui & Lobo 2008), we used the "pseudo-absence" approach. Pseudo-absence

Table 1: Environmental variables used to model the distribution of Caucasian Grouse in Arasbaran region, East Azerbaijan, Iran. – *Umweltparameter die zur Modellierung der Verbreitung des Kaukasusbirkhuhns in der dem Iran zugehörigen ost-aserbaidschanischen Region Arasbaran genutzt wurden.*

Variable – ***Variable***	**Abbreviation –** ***Abkürzung***	**Description –** ***Beschreibung***	**Source –** ***Quelle***
Land cover – *Landbedeckung*	CA_S1	proportion of the mosaic of shrub – mixed (shrub/tree) deciduous forest (canopy closure ≥ 50 %) – grassland – *Verhältnis des Mosaiks aus Buschland – Mischwald (Büsche/Bäume) (Kronenschluss ≥ 50 %) – Grasland*	FRWMO (2014)
	CA_S2	proportion of the mosaic of shrub – mixed (shrub/tree) deciduous forest (canopy closure < 50 %) – grassland – *Verhältnis des Mosaiks aus Buschland – Mischwald (Büsche/Bäume) (Kronenschluss < 50 %) – Grasland*	
	PR	Number of different patch types present within the landscape boundary (472 m radius) – *Anzahl unterschiedlicher Habitattypen innerhalb des definierten Untersuchungsraums (Radius 472 m)*	
Topography – *Topographie*	SLO	Percent of slope (maximum rate of change in elevation from each pixel to its neighbours) – *Prozentuale Geländeneigung (max. Änderungsrate der Höhenangabe zwischen benachbarten Pixeln)*	ASTER
	ASP	Cosine aspect – *Cosinus Aspekt*	
	ELV	Elevation – *Höhenlage*	

data were generated by randomly selecting 220 (ten times the number of confirmed presences; Chefaoui & Lobo 2008) analysis pixels for species that were not within 500 meter of any known locality of the species. This random selection was repeated five times to cover different gradients in the dataset of pseudo-absences (Thuiller *et al.* 2009, Barbet-Massin *et al.* 2012). We used the area under the receiver operating characteristic curve (AUC; ranging from 0.5 = random to 1 = perfect discrimination) as a threshold-independent criterion where values between 0.7–0.9 were considered as useful, and values > 0.9 as excellent (Fielding & Bell 1997). For classification accuracy, as threshold-dependent criteria, we considered true skill statistic (TSS) and Cohen's Kappa calculated for all models. For each model evaluation criteria were averaged among validation subsets of five replicates. Additionally, we applied a cross-validation procedure by randomly splitting the data into calibration (80 % of the data) and validation (20 %) datasets with five repetition runs to assess the stability of the model performance.

Finally, we combined concepts of both simple and complex modelling approaches into an ensemble model to deal with specific uncertainties of the SDMs and to maximize our understanding of the species distribution (Araújo & New 2007, Thuiller *et al.* 2009, Merow *et al.* 2014). The ensemble was built out of all modelling techniques with a weighting factor (decay = 1.6), giving higher importance to models with a better performance according to the TSS criterion (Thuiller *et al.* 2009). Importance, and thus the contribution of environmental variables to each model was examined regarding Pearson rank correlation between standard predictions and those based on 3-times random permutation for each variable separately (Thuiller *et al.* 2009). For each environmental variable we averaged variable importance across all implemented models. We also created partial dependence plots (visualizations of fitted functions) for the most informative variables in RF model.

Table 2: Evaluation of five modelling algorithms predicting the distribution of Caucasian Grouse in Arasbaran region. True skill statistic (TSS), area under the ROC curve (AUC) and Kappa value as well as standard deviation (SD) were measured based on averaging validation subsets of a 10 fold data splitting on Caucasian Grouse occurrences. – *Evaluierung von fünfAlgorithmen zur Modellierung der Verbreitung des Kaukasusbirkhuhns in der Region Arasbaran. Die statistischen Größen „true skill statistic" (TSS), „area under the ROC curve" (AUC) und Kappa-Wert, sowie Standardabweichung in Hinblick auf Vorkommen des Kaukasusbirkhuhns wurden basierend auf gemittelten Validierungsuntergruppen nach zehnfacher Datenunterteilung berechnet.*

Model	**AUC (SD)**	**TSS (SD)**	**Kappa (SD)**
GLM	0.77 (0.13)	0.56 (0.25)	0.53 (0.24)
GAM	0.87 (0.10)	0.72 (0.14)	0.66 (0.18)
MaxEnt	0.80 (0.06)	0.71 (0.12)	0.56 (0.12)
GBM	0.90 (0.06)	0.60 (0.13)	0.69 (0.15)
RF	0.92 (0.05)	0.74 (0.12)	0.75 (0.14)

3. Results

The distribution maps produced by each of the different models were almost indistinguishable. Similarly, the models were consistent in their predictions of the whereabouts of low quality habitat for CG (Fig. 1). However, models based on decision trees (e.g. GBM and RF) appear to be more conservative and GLM, GAM and MaxEnt more liberal in predicting landscape suitability (Fig. 1). Lacking a single best model based solely on evaluation metrics, the ensemble model highlights congruency among the model predictions (Fig. 1).

Overall performance of the models was good/moderate to excellent (Table 2) with performance met-

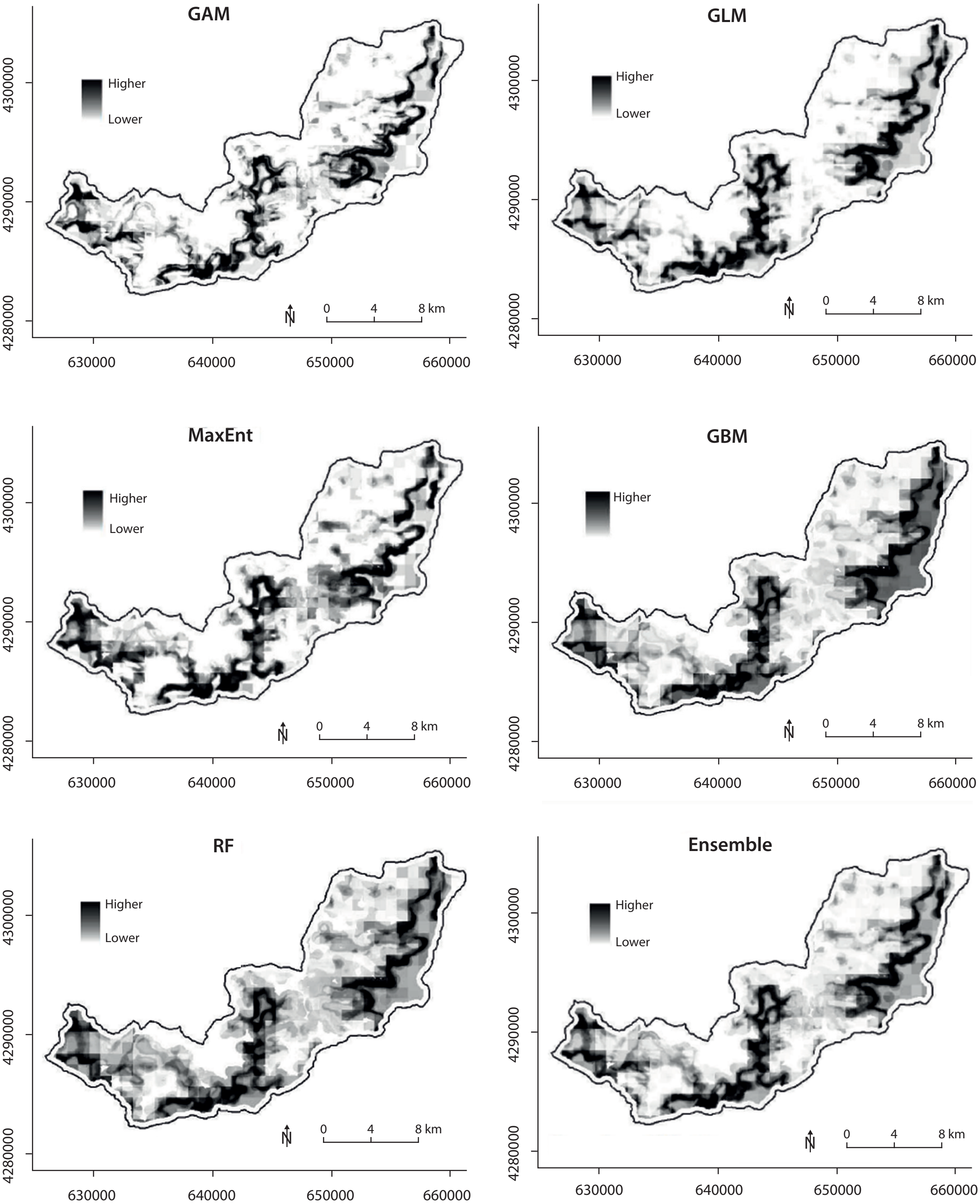

Fig. 1: Probability of Caucasian Grouse lek occurrence in its recorded distributional range in Arasbaran, Iran, obtained with GLM (generalized linear model), GAM (generalized additive model), MaxEnt (maximum entropy), GBM (generalised boosting model), RF (random forest) and Ensemble (consensus prediction across all models). – *Vorkommenswahrscheinlichkeit von Balzarenen des Kaukasusbirkhuhns innerhalb des bekannten Verbreitungsgebietes der Art in der iranischen Region Arasbaran basierend auf den folgenden Berechnungsmodellen: GLM (generalized linear model), GAM (generalized additive model), MaxEnt (maximum entropy), GBM (generalised boosting model), RF (random forest) und Ensemble (modellübergreifende Konsensvorhersage basierend auf den kombinierten Ergebnissen aller angewandten Modelle).*

Table 3: Mean and standard deviation (SD) of independent variable among the five models derived from BIOMOD. – *Mittlere Abweichung und Standardabweichung (SD) der genutzten unabhängigen Variablen der fünf verwendeten Modelle berechnet mit Hilfe des BIOMOD Softwarepakets.*

Model	GLM	GAM	MaxEnt	GBM	RF	Ensemble
ELV (SD)	0.53 (0.23)	0.52 (0.20)	0.51 (0.21)	0.55 (0.16)	0.36 (0.10)	0.56 (0.10)
ASP (SD)	0.05 (0.10)	0.24 (0.15)	0.22 (0.10)	0.02 (0.02)	0.02 (0.02)	0.05 (0.05)
SLO (SD)	0.07 (0.09)	0.37 (0.10)	0.31 (0.12)	0.03 (0.03)	0.03 (0.02)	0.10 (0.11)
CA_S1(SD)	0.30 (0.18)	0.49 (0.16)	0.41 (0.16)	0.13 (0.12)	0.13 (0.08)	0.22 (0.06)
CA_S2 (SD)	0.32 (0.19)	0.61 (0.13)	0.56 (0.15)	0.20 (0.12)	0.17 (0.05)	0.38 (0.20)
PR(SD)	0.14 (0.13)	0.23 (0.16)	0.10 (0.09)	0.01 (0.01)	0.01 (0.01)	0.07 (0.07)

rics lower for the GLM model and higher for the RF model for all threshold-dependent metrics. TSS scores of 0.56–0.74 indicated that the accuracy of all models was good, according to Allouche *et al.* (2006). Cohan's Kappa statistic was higher than 0.5 for all models (Landis & Koch 1977). Model discriminatory ability of the RF model can be classified as excellent based on AUC values, while MaxEnt, GLM, GAM and GBM can be classified as moderate (Swets 1988; Table 2).

Based on the mean value of variable importance given by BIOMOD, the variables ELV, SLO, CA_S1 and CA_S2 achieved the highest importance values, whereas ASP and PR variables were of low important in all models (see Table 3).

The response curves produced for these most important variables were almost indistinguishable for the RF model (Fig. 2). These response curves indicated that the likelihood of the CG lek occurring increased with increasing altitude as well as slope. Additionally, lek occurrence was more likely in areas characterized by higher percent cover of the mosaic of mixed deciduous forest (canopy closure ≥50 %) and grassland and

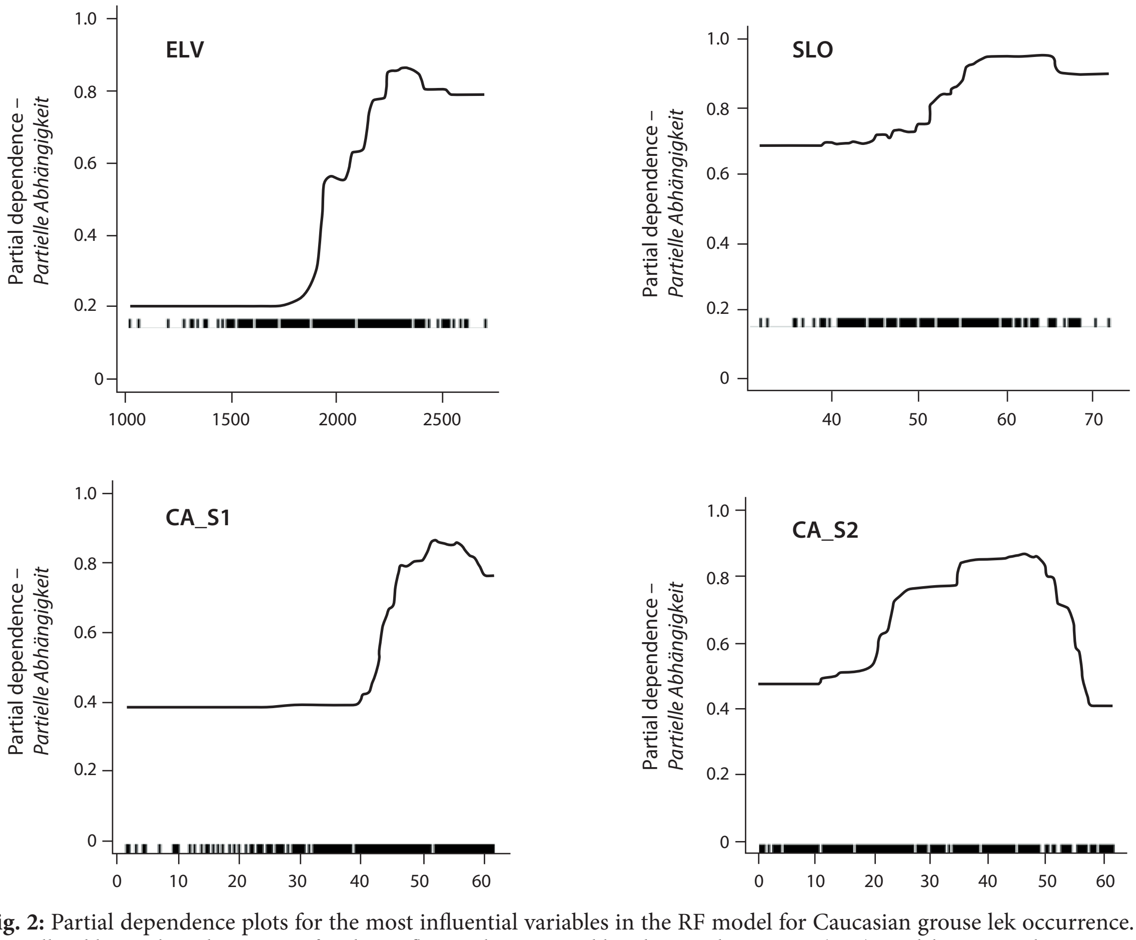

Fig. 2: Partial dependence plots for the most influential variables in the RF model for Caucasian grouse lek occurrence. – *Partielle Abhängigkeitsdiagramme für die einflussreichsten Variablen des Random Forest (RM) Models zum Vorkommen von Balzarenen des Kaukasusbirkhuhns.*

low to moderate percent cover of the mosaic of mixed deciduous forest (canopy closure < 50 %) and grassland (Fig. 2).

The distribution probability scores calculated for the ensemble model ranged from 10 to 854. We set the minimum threshold for suitability of habitat for CG at a probability of occurrence equal to 405. On this basis, a total area of 5064 ha was identified as suitable habitat for CG, representing 16 % of the study area (overall size = 31654 ha) (Fig. 3).

4. Discussion and conclusions

Our results indicated that altitude and slope are key determinants underlying the spatial distribution of CG in this region. During leking altitude and slope appears to be the main factors determining the spatial distribution of this subalpine species. Our results are in line with previous reports (Gottschalk *et al.* 2007, Gavashelishvili & Javakhishvili 2010) and clearly confirm that altitude and slope are of great importance for determining CG distribution.

Highly suitable areas were found to be located mainly in landscapes that have ideal proportions of closed and open deciduous stands creating several suitable patches accompanied by grassland. These habitats close to lek sites could permit more efficient foraging and provide both, excellent protections from avian predators and facilitated flutter jump behaviour for male grouse. Both aspects are in agreement with knowledge on CG landscape requirements at 500-m radii scale published by Habibzadeh *et al.* (2013). Gavashelishvili & Javakhishvili (2010) also indicated the importance of proximity to deciduous broad-leaved forest, but did not specify what canopy cover is most suitable.

Our model showed that CG distribution is shaped by three distinctive suitable landscape characteristics. This result indicates that the CG population may be distributed in a meta-population pattern. Future research into population genetic can assess the validity of this assumption.

SDM is currently the main method for predicting species distributions, which in turn may guide conservation management actions. In addition, the IUCN recently began to explicitly incorporate SDMs to estimate distributional range as a parameter to assess the risk of extinction and to explore potential impacts of climate change on species distribution (Cassini 2011). Here we have used a combined modelling methodology to describe the potential distribution of CG. Using this approach we have been able to integrate both, landscape metrics, such as the proportion of different habitat types and patch richness, and drivers of topography to present a better understanding of the species range. This is in agreement with previous studies showing that landscape metrics and topographic changes affect the species distribution (Gavashelishvili & Javakhishvili 2010, Habibzadeh *et al.* 2013, 2010). With this in mind, we built combined models and provide a comprehensive map of the potential distribution. This map will help to inform efforts of the annual monitoring programme of the Iranian Department of Environment (DOE) and help determining new survey locations. Additionally, models can contribute to important habitat management decisions, such as the identification of locations that might be most suitable for habitat restoration efforts. Our method does not assess human and domestic animal disturbance at lek sites, thus it could be that many sites appearing suitable according to our models may face high disturbance levels making them unattractive as breeding sites for CG. Future

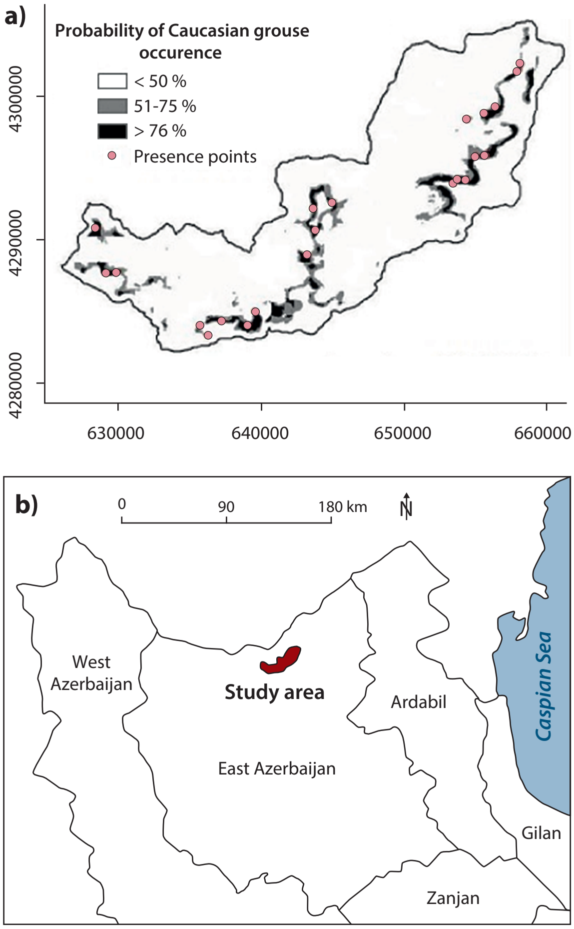

Fig. 3: Map a) Predicted distribution of Caucasian Grouse according to the ensemble model. Geographic extent of lek records and habitat modelling for Caucasian Grouse in Arasbaran, Iran. Map b) indicates the study area and the surrounding provinces in Iran as well as the bordering Caspian Sea. – Karte a) *Modellierte Verbreitung des Kaukasusbirkhuhns nach dem kombinierten Model. Räumliche Verteilung von nachgewiesenen Balzarenen und Habitatmodellierung für die iranische Region Arasbaran. Karte b) verortet das Untersuchungsgebiet sowie die angrenzenden iranische Provinzen und das Kaspische Meer.*

work should focus on including these factors into a similar analysis. Suggested future actions include efforts to ground-truth the model results. For example, biologists familiar with CG habitat requirements should visit sites with a high likelihood of occurrence according to the model but currently do not support breeding CG to evaluate model usefulness and accuracy.

Including all spatially referenced occurrence locations of a species across the habitat niche occupied is of limited value for informing conservation measures without considering population demography (e.g. survival probability). Therefore, if ecological niche modelling with presence/absence data is applied without accounting for source/sink dynamics, the results will include areas likely to serve as population sources or sinks (Kahler & Cavalieri 2014). Thus, we advocate a multi-scale approach for the management of CG. For example, managers should consider studying population viability and demography in conjunction with fine-scale habitat variables and landscape patterns.

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5. Zusammenfassung

Habibzadeh, N. 2017: Modellierung der potenziellen Verbreitung des Balzhabitats des Kaukasusbirkhuhns *Lyrurus mlokosiewiczi* im Iran. Vogelwelt 137: 184–193.

Das Monitoring sowie der Schutz einer möglichst großen Anzahl von Balzarenen des Kaukasusbirkhuhns sind von großer Wichtigkeit für ein besseres Management dieser endemischen Art des Kaukasus. Eine Voraussetzung für den besseren Schutz der Art ist ein detaillierteres Verständnis seiner Lebensraumansprüche. Im Rahmen der hier vorgestellten Studie wurde das potenzielle Vorkommen geeigneter Balzhabitate der Art in der iranischen Region Arasbaran mit Hilfe von verschiedenen Artverbreitungsmodellen untersucht. Fünf Modelle mit unterschiedlichen Stärken wurden zur Modellierung herangezogen und die Ergebnisse in einem kombinierten Modell zusammengefasst. Sechs Umweltparameter zur Charakterisierung von Habitaten und Topographie wurden herangezogen. Die verschiedenen Modelle zeigten eine hohe Übereinstimmung im Hinblick auf die Identifizierung potenziell geeigneten Balzhabitats. Höhenlage sowie die Neigung des Geländes konnten als Haupteinflussgrößen für die Verbreitung des Kaukasusbirkhuhns in der Region identifiziert werden. Zudem konnte gezeigt werden, dass Habitate mit hoher Bedeckung aus einem Mosaik aus Mischwald, bestehen aus Büschen und Bäumen (Kronenschluss ≥ 50 %), und Grasland als auch Habitate mit geringer bis mittlerer Bedeckung aus einem Mosaik aus Mischwald (Kronenschluss < 50 %) und Grasland, mit erhöhter Wahrscheinlichkeit für Balzarenen genutzt werden. Die aus Basis des kombinierten Modells erzeugte Verbreitungskarte kann zur Benennung von prioritären Bereichen für den Schutz der Art genutzt werden. Die Ergebnisse dienen zudem dazu die Erhebungen im Rahmen des jährlichen Artmonitorings im Iran auf potenziell relevante Bereiche zu konzentrieren und Flächen für Renaturierungsmaßnahmen identifizieren. Das Modell soll zukünftig, wenn möglich, um den Aspekt der Störungen durch Menschen und Weidetieren erweitert werden, der bisher nicht berücksichtigt werden konnte, aber vermutlich eine große Relevanz hat. Um zu überprüfen ob Bereiche die laut Modell geeignetes Habitat bereithalten sollten möglicherweise durch regelmäßige Störungen unattraktiv für das Kaukasusbirkhuhn sind, sind Felduntersuchungen zur Verifizierung der Modellergebnisse geplant.

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Long-term changes in population and habitat selection of Red Kite *Milvus milvus* in the region with the highest population density

Bernd Nicolai, Ubbo Mammen & Martin Kolbe

Nicolai, B., U. Mammen & M. Kolbe 2017: Long-term changes in population and habitat selection of Red Kite *Milvus milvus* in the region with the highest population density. Vogelwelt 137: 194–197.

The Red Kite is unique among the about 260 native German breeding bird species, in that half of its worldwide population occurs in Germany. Saxony-Anhalt is the federal state with the highest population density. About 2,000 pairs (8 % of the global population) currently nest across its territory. The highest Red Kite population density is found within the region north of the Harz Mountains where data have been recorded every five years since 1986. During the investigation changes in abundance and habitat selection were observed. The number of breeding pairs decreased in forests and seems to be stable in the open countryside. Additionally, the number of Red Kites nesting near urban areas is increasing. The detected development indicates that the food availability may be better in built-up areas than in agricultural areas. This development is alarming as the Red Kite, a typical species of the agricultural countryside, seems to experience poor feeding conditions in its natural habitat. If food availability for Red Kite does not increase in the near future, a further decline of the Red Kite population is likely. Improvements of natural Red Kite habitats are needed and would also benefit many other threatened farmland bird species.

Keywords: Red Kite *Milvus milvus*, population dynamics, habitat selection, Saxony-Anhalt

1. Introduction

The Red Kite is the most remarkable of all breeding birds in the Federal Republic of Germany. It is unique among the about 260 native species of breeding birds as about half of the global population occurs in Germany. The area supporting the highest population density is located in the federal state of Saxony-Anhalt. About 2,000 pairs (8 % of the global population) currently nest in Saxony-Anhalt (Mammen *et al.* 2014). Particularly high Red Kite densities are found in the region north of the Harz Mountains.

Number and distribution of Red Kites in this region are well known for more than 50 years. In the past, almost all breeding pairs nested in isolated forests (Hakel, Huy, Hohes Holz) and nearly none in the open countryside. Formerly the farming of highly productive soils provided good food supply for Red Kite and its population increased for several decades (Stubbe & Zörner 1993). The highest population density of more than 40 BP/100 km^2 was recorded in 1990/91. Thereafter, in the course of only five years and as a result of extreme changes in agricultural practices, the population declined by nearly 50 % between 1991 and 1996 (Nicolai 2006, Nicolai 2011, Nicolai *et al.* 2009). Focusing on this region supporting the highest Red Kite population density across its distributional range, this paper presents the population development and observed changes in habitat selection of Red Kites between 1986 and 2016.

2. Study area and methods

The study area is located in the north of the Harz Mountains, the region with the highest density of breeding Red Kites (Fig. 1). The surveyed area covers 445 km^2 and consists primarily of open countryside without forests. The landscape is dominated by arable land with field sizes up to 90 hectares and is crossed by small riverine meadows. Large pastures are found only in the north of the study area.

Across the study area the populations of all raptor species have been documented every five years since 1986. Population estimates are based on nest searches. Additionally, precise location, nest site, nest height and nesting tree species were recorded. QGIS (Version 2.14.1) was used for data digitization. Supplementary data on the Red Kite population in the surrounding forests were obtained from the 'Monitoring of European Raptors and Owls' (MEROS). To estimate the influence of land use on the Red Kite population, official land use data for Saxony-Anhalt were used and categorised into seven main types. The nest environment was defined as a radius of 500 m around the nesting site. Statistics were evaluated using R (Version 3.0.1).

3. Results

Within the study area Red Kites started to populate the open countryside in the early 1970s (see Fig. in Nicolai 1997). The proportion of breeding pairs nesting in the forests surrounding the study area decreased while numbers in the open countryside increased (Fig. 3). The Red Kite population in the study area increased strongly until 1991 and subsequently suffered a dra-

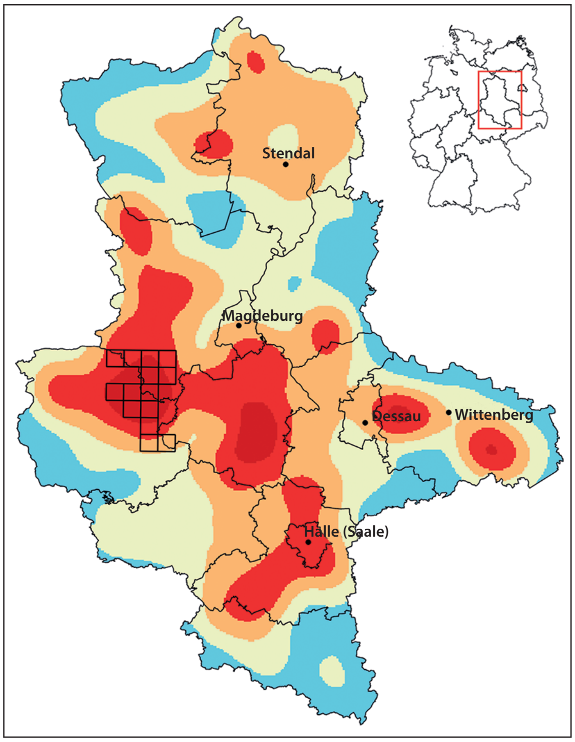

Fig. 1: Location of the study area (grids) and main Red Kite concentration areas (areas marked red support high, blue comparatively low numbers) in Saxony-Anhalt based on MAMMEN *et al.* (2014). – *Die Lage des Untersuchungsgebiets (Gitterfelder) und die Schwerpunktvorkommen des Rotmilans (rot markierte Bereiche weisen viele, blau markierte vergleichsweise wenige Vorkommen auf) in Sachsen-Anhalt nach MAMMEN* et al. *(2014).*

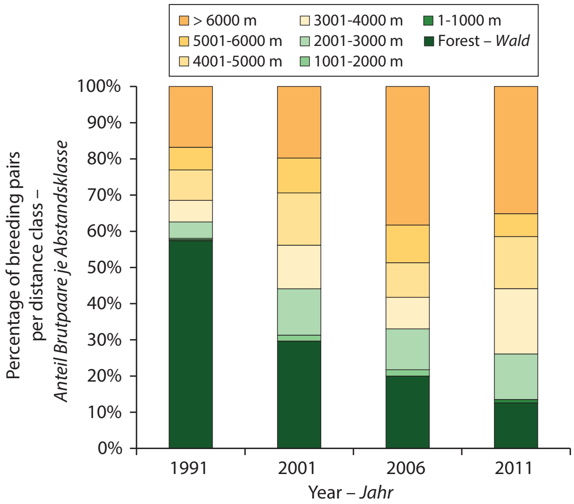

Fig. 3: Percentage of Red Kite breeding pairs nesting in forests and in different distance classes with relation to the nearest forest. – *Prozentuale Anteile der in Wäldern nistenden Rotmilane sowie die Anteile innerhalb mehrerer Abstandsklassen zum nächstgelegenen Wald.*

matic decrease. Since 2001 the population comprising about 100 breeding pairs remained stable (Fig. 2). During the same period changes in habitat selection were observed. The proportion of built-up areas within the nest environment considerably increased ($p<0.005$) (Fig. 5). The number of breeding pairs nesting within towns and villages ($p<0.01$) and a 500 m periphery ($p<0,005$) increased, while the number of breeding pairs within a distance between 500 and 1,000 m to towns and villages decreased ($p<0.01$) (Fig. 5). Today, about two thirds of the Red Kite population nest in or near settlements; at the start of the study period it was only slightly more than one third of the breeding pairs. Moreover, it was noticed that the height at which Red Kites built their nest in trees increased during the study period (Fig. 6).

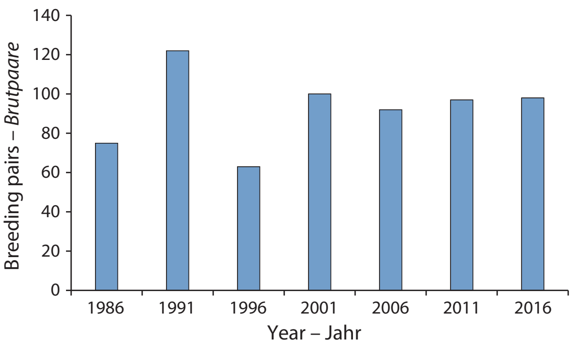

Fig. 2: Number of Red Kite breeding pairs in a 445 km^2 study area in the north of the Harz Mountains. – *Anzahl der Rotmilanbrutpaare im 445 km^2 großen Untersuchungsgebiet im nördlichen Harz.*

4. Discussion

The study area consists predominantly of intensively used arable land. The farmland is regularly crossed by rows of Poplar trees *Populus* spec. These trees were planted in the 1950s and 1960s for wood production and to protect the fields from wind erosion. By the mid-1970s these trees had grown sufficiently in height

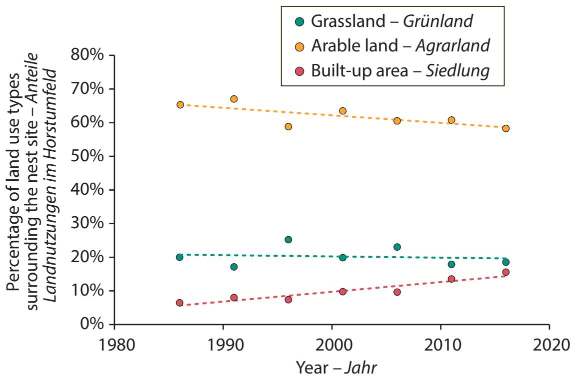

Fig. 4: Changes in percentages of grassland (n. s.), arable land (n. s.) and built-up areas ($p<0.005$) within the nest surroundings. – *Änderungen der prozentualen Anteile von Grünland (nicht signifikant), Agrarland (nicht signifikant) und Siedlungen ($p<0,005$) im Umfeld von Rotmilanhorsten.*

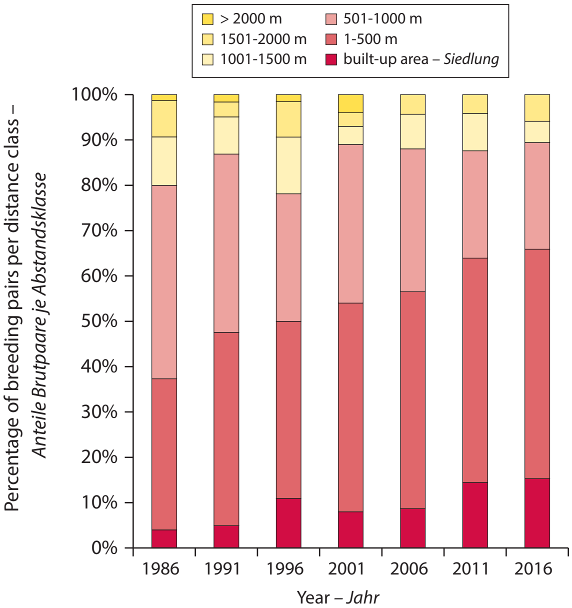

Fig. 5: Percentage of Red Kite breeding pairs in distance classes to built-up areas during the study period (in built-up areas p < 0.01; 1-500 m p < 0.005; 501-1000 m p < 0.0005; other n. s.). – *Prozentualer Anteil von Rotmilanbrutpaaren innerhalb mehreren Abstandsklassen zu Siedlungen im Untersuchungszeitraum (innerhalb von Siedlungen p < 0,01; 1-500 m p < 0,005); 501-1000 m p < 0,0005; weitere nicht signifikant).*

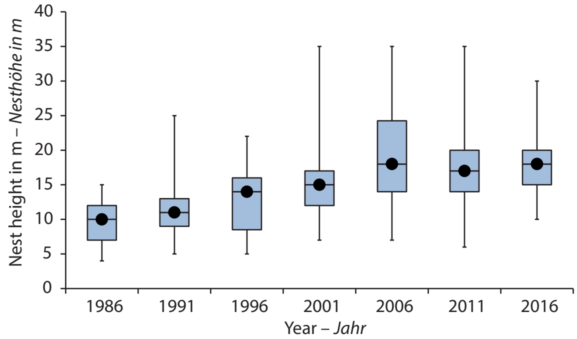

Fig. 6: Changes in Red Kite nesting height in the study area during the study period. The upper and lower quantiles are shown as lines. The mean value is represented as a line within the boxes, while the median is shown as a point. – *Änderungen der Nesthöhe des Rotmilane im Untersuchungsgebiet im Untersuchungszeitraum. Die oberen und unteren Quantile sind als Linien dargestellt. Der Mittelwert ist als Linie innerhalb der Boxen dargestellt, der Median als Punkt.*

to represent suitable nesting sites for raptors (Bley *et al.* 2015). At that time the greater part of the Red Kite population bred in the forests surrounding the survey area (Stubbe 1982, Stubbe & Zörner 1993). With increasing availability of nesting sites outside the forests a relocation of the Red Kite population took place.

After 1991 changes in agricultural practices reduced the food availability for Red Kites. As a consequence, reproduction dropped rapidly, causing a regional population decrease (Nicolai & Böhm 1999). While the population breeding in the open countryside remained more or less stable, the Red Kites breeding in forests further declined (Weber *et al.* 2009). Today nearly 90 % of the regional Red Kite population nests in the open countryside.

Additionally, nesting height increased until 2006 and since then remains almost stable. This development can be explained by the growth of the Poplar trees mainly used as nesting sites. At the beginning of the study period, the majority of Poplar trees had just reached an age suitable to provide nesting habitat for Red Kite. In the following years, they grew to their maximum height. The mean age and mean height of these trees increased during the study period, as only few new trees were planted (Bley *et al.* 2015). The limited lifespan of Poplar trees (max. 100 years) currently becomes a serious problem. Within the study area most Poplar trees will disappear within the next 20 years. New nesting sites in younger trees are rare and consequences for the Red Kite population remain unclear. It appears possible that the local Red Kites may re-colonise their historic nesting sites in the surrounding forested areas. In the worst case the population of this threatened species will further decline.

Furthermore, a change in habitat selection was observed for Red Kites. Fig. 4 and 5 illustrate an increasing amount of Red Kites breeding in or near towns and villages. Although Red Kites breeding in built-up areas were already observed during the 1990s (Hellmann 1999), a markedly increasing trend has been detected in recent years. The reasons for this are unknown, but it can be assumed that food availability within settlements may be better than in the open agricultural countryside where areas available as feeding grounds during the breeding season are becoming increasingly rare. Direct observations and anecdotes from local people suggest that Red Kites are fed selectively at various places. Similar cases are known from the UK, where Red Kites receive supplementary feeding in domestic gardens, thus explaining the presence of birds in towns (Orros & Fellowes 2015). A similar situation can be assumed for our study region. This development is alarming as the Red Kite, a typical species of agricultural landscapes, experiences poor feeding conditions in its natural habitat and becomes a synanthrope. Today, almost two thirds of the recorded breeding pairs breed in settlements or in their immediate vicinity. It must therefore be assumed that these birds, at least partly, profit from domestic food sources. If food availability for the species remains at a low level, a further decline of the Red Kite population appears likely.

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5. Zusammenfassung

Nicolai, B., U. Mammen & M. Kolbe 2017: Langfristige Veränderungen der Population und Habitatwahl beim Rotmilan *Milvus milvus* in der Region mit der höchsten Populationsdichte. Vogelwelt 137: 194–197.

Der Rotmilan *Milvus milvus* ist die einzige der 260 deutschen Brutvogelarten, von der über die Hälfte der Weltpopulation in Deutschland vorkommt. Das Bundesland mit der höchsten Siedlungsdichte ist Sachsen-Anhalt. Derzeit brüten dort etwa 2.000 Paare, was ca. 8 % der Weltpopulation entspricht. Im nördlichen Harzvorland, dem Gebiet mit der weltweit höchsten Siedlungsdichte, wurde seit 1986 alle fünf Jahre der Bestand des Rotmilans erfasst. Neben Veränderungen im Bestand konnten im Laufe der Untersuchung auch ein Wandel der Siedlungsstruktur beobachtet werden. Im Zeitraum der Untersuchung ging der Brutbestand in den Wäldern stark zurück, während der Bestand im Offenland langfristig stabil zu sein scheint. Wie aus den Ergebnissen hervorgeht brüten Rotmilane zunehmend in der Nähe von Siedlungen. Das deutet darauf hin, dass die Nahrungsversorgung in der Agrarlandschaft schlechter ist als in Siedlungen. Wenn sich die Nahrungsverfügbarkeit in der Agrarlandschaft nicht bald verbessert, wird dies in Zukunft zu einem weiteren Rückgang der Rotmilanpopulation führen. Die Verbesserung des natürlichen Habitats des Rotmilans würde auch den Bestandsrückgang vieler weiterer bedrohter Feldvogelarten aufhalten.

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Avifauna of Tver Region (Russia) – Its past and present

Andrei V. Zinoviev

Zinoviev, A. V. 2017: Avifauna of Tver Region (Russia) – Its past and present. Vogelwelt 137: 198–200.

Aside of scarce reports on birds of the Tver Region in medieval and 18th century sources, the real monitoring of the regional fauna has started in the second half of the 19th century. Since the first relatively long list of birds, which contained 154 avian species and was published by A. Dyakov in 1878, the number of birds recorded in the Tver Region has increased to 275 species. Although not all of them are nesting or have nested in the region, bird populations and their distribution dynamics show certain trends during the last one and a half centuries. The beginning of 20th century in the Tver Region was marked by the presence of a number of species typical for the more southern forest-steppe regions. Roller and Scops Owl, as well as Bee-eater have never been recorded nesting in those numbers again. White Stork started to nest in the region in 1930s and since then has expanded its nesting range over the entire region; today the White Stork breeding population is estimated to comprise 200–230 pairs. Collared Dove populated the Tver Region in the 1970s and reached a population peak in the 1980s, when the region harboured about 100 nesting pairs. The number of doves abruptly declined during the early 1990s and today the species completely disappeared from the region. Turtle Dove demonstrates a similar case. Being numerous by the end of the1980s the species almost disappeared from the Tver Region. These and other results of the long-term monitoring of birds in the Tver Region show that population and distribution dynamics are not only related to climate changes, but also to the type and intensity of human activities.

Keywords: avifauna, Tver Region, history, dynamics, agriculture

1. Introduction

Tver Region (Tver Oblast) is located in the centre of the East European Plain (Fig. 1) and covers about 84,100 km^2. It represents the largest region of the Central Federal District. Being as large as Austria it has a variety of natural resources and habitats. Lowlands alternate with highlands covered with peat bogs, meadows as well as temperate and southern taiga forests. The region includes the major part of the so called Valdai Hills, representing the watershed of the Caspian, Baltic and Black Seas. Numerous rivulets, rivers and lakes characterise the Tver Region. The fauna and flora are similar to those of the bordering Moscow, Smolensk, Pskov, Novgorod, Vologda and Yaroslavl Regions. The avifauna of the region has been monitored for the last 140 years (Dyakov 1878).

Fig. 1: The location of the Tver Region (red) within Russia (courtesy of Nicolay Sidorov). – *Die Lage der Twer Region innerhalb Russlands.*

2. History

First scarce reports on birds inhabiting Tver Region can be found within the notes of medieval travellers (after Kutepov 1896, 1898). However, the first more or less detailed account was provided by the academic I. A. Güldenstädt (1878), who travelled along the rivers Polomet and Msta located on the border of today's Tver and Novgorod Regions. He mentioned 41 species of birds. The academic N. Ya. Ozeretskovsky (1817) added three more species to this list. Data on bird hunting were reported by several huntsmen (Wildermet 1834, 1838, 1842, Baikov 1901, Funtikov 1915). A. I. Dyakov (1878) published the first bird list of the Tver Province. It contained 154 species of birds (161 when combined with data of previously mentioned authors). V. Esaulov (1878) expanded this list to 185 species, providing the first classical annotated checklist of birds of the Toropets District of the Tver Province. The next author adding species to the bird list of the Tver Province was K. N. Davydov (1896). He described the birds of the Rzhev District, adding eight new species (193 in total) to the list. Substantial works of N. A. Zarudny (1910) comprise data on a further 63 bird species new to the Tver Province (256 in total). Moreover, this author mentioned the possibility that additional species could enter the province as vagrants. Another species (257 in total) was added by N. M. Tyulin (1914), recorded when travelling to his mansion in the Bezhetsk District. V. L. Bianki (1922) recorded two new species, which he observed in the north-west of the Tver Province, expanding the bird list to 259 species. No new records followed until 1928, when another new species was added to the list of birds (260 in total) (Kaplanov & Raevsky 1930). A. V. Tretyakov (1940) published the second annotated checklist of bird of the Kalinin Region (the Tver Province was renamed to Tver Region (Oblast) in 1929 and to Kalinin Region in 1935; the name Tver Region was returned in 1990). This list contained 261 species. Studies carried out during the second half of the 20th century and the beginning of the 21st century expanded the list of birds of the Tver Region to 267 species (for further references see Zinoviev *et al.* 2016).

3. Trends

The analysis of the aforementioned sources demonstrates certain trends in the avifauna of the Tver Region during the last one and a half centuries.

The first trend relates to climatic changes and changes in human activities. Reports from the first decade of the 20th century indicate the presence of a number of avian species in the Tver Region typical for the more southern forest-steppe regions (Grave 1927). Roller *Coracias garrulus* and Scops Owl *Otus scops*, as well as Bee-eater *Merops apiaster* have never been recorded nesting in those numbers again. The beginning of the 20th century in the region was quite warm and dry; during this period the agricultural land expanded continuously from the forest-steppe regions, especially along the large rivers. Occasional warmer and dryer seasons in the 1960s and the 2000s resulted in increased numbers of the species mentioned above (Vinogradov & Vinogradov & Zinoviev 2014). However, these species never reached the numbers recorded at the beginning of the 20th century, as the number of comparably warm and dry years was not frequent enough and due to the general decline of agriculture in the Tver Region in the 2000s.

The occurrence of White Stork *Ciconia ciconia* in the Tver Province was first mentioned by V. L. Bianki (1922). The species started to nest regularly during the 1930s, spreading across the region in a north-eastern direction (Zinoviev *et al.* 1990). By the 1980s the White Stork occupied the basins of Volga, Tvertsa and Upper Mologa rivers, reaching its population peak during the 1990s. Today, the number of nesting birds is estimated to comprise 200–230 pairs (Nikolaev 2000). The White Stork population in the region is quite stable, though showing the tendency to decline as a consequence of the loss of appropriate feeding and nesting ground due to the degradation of villages and pastures (Zinoviev & Koshelev 2013).

Two dove species demonstrate interesting dynamics in the Tver Region. Collared Dove *Streptopelia decaocto* populated the Tver Region in the 1970s and reached a population peak in the 1980s, when the region harboured about 100 nesting pairs (Butuzov *et al.* 2002). This dynamic appears to represent the general trend of this species during that period (Blagosklonov 1978, Nowak 1989). The number of doves abruptly declined at the beginning of the 1990s due to unknown reasons; today the species completely disappeared from the region.

Turtle Dove *Streptopelia turtur* demonstrates a similar case, though representing a native species of the Tver Region. Being numerous by the end of 1980s it has now almost disappeared from the Tver Region. This development coincides with a decline of agricultural areas, representing typical Turtle Dove feeding habitat.

These and other results of the long-term monitoring of birds in the Tver Region show that population and distribution dynamics do not only relate to climate changes, but also to the type and intensity of human activities.

4. Zusammenfassung

Zinoviev, A. V. 2017: Die Avifauna der Twer Region (Russland): Vergangenheit und Gegenwart. Vogelwelt 137: 198–200.

Abgesehen von vereinzelten Berichten zur Vogelwelt der Twer Region aus dem Mittelalter sowie dem 18. Jahrhundert, begann die gezielte Untersuchung der regionalen Vogelfauna in der zweiten Hälfte des 19. Jahrhunderts. Seit der Publikation einer ersten verhältnismäßig umfassenden Liste der vorkommenden Vogelarten im Jahr 1878 durch A. Dyakov, die 154 Arten umfasste, stiegt die Anzahl der nachgewiesen Vogelarten in der Zwischenzeit auf 275 Arten an. Nicht bei allen Arten konnten Brutnachweise erbracht werden. Die Populationen selbst und deren Verbreitungsdynamik im Betrachtungsgebiet zeigen deutliche Trends über die zurückliegenden eineinhalb Jahrhunderte. Der Beginn des 20. Jahrhunderts war in der Twer Region durch das Auftreten verschiedener Arten gekennzeichnet, die typischerweise in der weiter südlich gelegenen Waldsteppenregionen vorkommen. Arten wie die Blauracke, Zwergohreule und Bienenfresser wurden niemals wieder in so hoher Zahl als Brutvögel festgestellt. Der Weißstorch besiedelte die Region in den 1930er Jahren. Seither hat sich die Art in der gesamten Region als Brutvogel etabliert, so dass der Brutbestand heute auf 200–230 Brutpaare geschätzt wird. Darüber hinaus zeigen zwei Taubenarten interessante Entwicklungen auf. Die Türkentaube besiedelte die Twer Region in den 1970er Jahren und erreichte in 1980er Jahren ein Bestandshoch mit etwa 100 Brutpaaren. In den frühen 1990er Jahren zeigte die Art dann einen abrupten Bestandseinbruch und ist heute völlig aus der Region verschwunden. Bei der Turteltaube zeigte sich ein ähnliches Bild. Während die Art Ende der 1980er Jahre zahlreich vorkam, ist sie heute fast vollständig aus der Region verschwunden. Diese und weitere Ergebnisse des Langzeit-Monitorings der Avifauna der Twer Region zeigen, das Populations- und Verbreitungsdynamiken nicht ausschließlich durch klimatische Änderungen bedingt sind, sondern ebenfalls stark durch die Art und Weise sowie Intensität anthropogener Aktivitäten beeinflusst werden.

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The West African Bird DataBase – a tool for conservation, also of intra-African and Palearctic migratory birds

Ulf Liedén & Joost Brouwer

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Many Palearctic breeding birds spend the northern winter in sub-Saharan Africa (SSA), a vast region with very few birdwatchers that also hosts many resident birds and intra-African migrants. Land use and land use change in SSA are mostly determined by local people, rather than by national governments. If birds are to be conserved effectively, those local people need to be involved, and more effort and money from Europe need to go into conservation in Africa. The West African Bird DataBase (WABDaB) www.wabdab.org is a tool for the conservation of all birds in West Africa. It is online, open-access, and bilingual (French and English) and as of 1st September 2016 covers Niger, Chad and Burkina Faso. Both current and historical bird records can be uploaded, including any available photos. Records and/or maps can be extracted based on species, geographic unit, time unit (time of year and defined period of years) or contributor. Relevant national ministries have complete access to the data. For use for commercial purposes a fee must be paid. The website also contains national checklists, a list of relevant literature, and documents on the separation of difficult species pairs. As a means of involving local people, names and stories of birds in local languages and cultures are collected. Because of changes in societies, this information is in danger of becoming lost. Ideas for the future of the WABDaB include the visualisation of the results of bird migration studies, that e.g. show Niger to be connected by migrating birds to at least 93 other countries, among them almost all African, European and Middle Eastern countries, as well as NE Canada/Greenland/Iceland, eastern Russia and Kazakhstan.

Keywords: migratory birds, sub-Saharan Africa, online database, conservation tool

1. Introduction – comparing Europe and (West) Africa

If Europeans want their migratory birds to come back from Africa, they should help make sure that those birds survive in Africa. In our opinion that means that much more time and money should be spend on promoting knowledge and conservation of birds in Africa, rather than in Europe. In this contribution we focus on birds in the Sahelian part of West Africa, but our general conclusions are also relevant to other parts of Africa.

In Europe there are thousands of professional ornithologists and tens of thousands of citizen scientists helping improve knowledge on birds and how best to protect them. Because of the way the spherical surface of the earth is projected onto a flat sheet, most maps of the world make Europe look much larger in comparison with Africa than it really is. Maps designed using equal area projection, e.g. the Gall-Peters projection (https://en.wikipedia.org/wiki/Gall%E2%80%93Peters_projection) show that just two West African countries, Niger and Chad, each about 1,250,000 km² in size, are together larger than Portugal, Spain, France, Italy, Switzerland, the Benelux countries, Germany and Poland combined. To the best of our knowledge, Niger and Chad have only two or three resident bird watchers each.

In Africa, like in Europe, land use is a major determinant of suitability of habitats for particular bird species (Atkinson *et al.* 2014, Vickery *et al.* 2014). Fig. 1 shows what the landscape in the Sahel, on the southern border of the Sahara, looks like in September-October, at the end of the rainy season, when migratory birds from Europe arrive.

After crossing the Sahara, the Sahel is like one big oasis to those birds: green, with lots of seeds and insects to feed on, plenty of water, plenty of shade, and agreeable temperatures with cool nights. How different it is when the birds go north again in March-April, at the end of the dry season.

Fig. 2 shows the same landscape as Fig. 1 (compare the trees), but by March it is brown, there is little to eat for the birds, there is little water, there is hardly any shade, and temperatures soar to 45 °C during the day, remaining above 30 °C at night. The birds seek shelter wherever they can, sometimes under parked cars or in one of the very few watered gardens in the scattered towns of the Sahel. There Garden Warblers *Sylvia borin*, Reed Warblers

Fig. 1: Landscape in the Sahel near Mainé-Soroa, SE Niger, 3rd October 2010. Copyright David Kusserow. – *Landschaft in der Sahelzone nahe Mainé-Soroa, Süd-Ost Niger, 3. Oktober 2010.*

Acrocephalus scirpaceus, Whinchats *Saxicola rubetra*, Golden Orioles *Oriolus oriolus*, Redstarts *Phoenicurus phoenicurus* etc. on their way north can sometimes be picked up by hand, so exhausted are they. Not surprisingly, Haussa in central Niger call those small migratory birds 'the birds that cannot stand the heat'.

Note that Fig. 2 was actually taken six months before Fig. 1. The greening, drying out and re-greening of the landscape in the Sahel is an annually recurring cycle. There are, however, limits to how much drought a landscape can take and still bounce back. It is very important for the survival of European migratory birds that the right habitat remains or is re-created in the Sahel, especially at the time of northward migration (Atkinson *et al.* 2014, Vickery *et al.* 2014).

When one talks about habitat, habitat management and habitat re-creation, one must of necessity also talk about people. It is the local land users that determine what the landscape looks like. For these people assuring themselves of the basic necessities of food, water and shelter, all year round, often takes much of their time. Certain birds have a role in their culture, but many birds are more likely to be seen as a source of protein than as something to be protected. In Niger and Chad population growth has been around 3 % per year (http://en.wikipedia.org/wiki/List_of_countries_by_past_and_future_population), which means a doubling of the population in less than 25 years. More people means that more land is needed to grow the crops to feed them. This means less land suitable for birds, unless a way is found to accommodate food production and birds on the same land. The latter is a very important way of stimulating the local people to become involved in bird conservation.

2. The West African Bird DataBase and the ornithological information it contains

To increase the knowledge of birds in West Africa, and to increase the interest of local people in birds, the on-line open-access, bilingual (French and English) West African Bird DataBase (WABDaB) was founded. It was started in 1994 as the Niger Bird DataBase and went on-line in 2010. In 2015 Chad and Burkina Faso were added and the name changed to West African Bird DataBase at www.wabdab.org. After a simple registration procedure to allow feedback from the WABDaB administrators, contributors can add records of birds seen in one of the three countries. Minimum information required are species name, date and location (locality name and/or

Fig. 2: The same landscape in the Sahel near Mainé-Soroa, SE Niger, 31st March 2010. Copyright David Kusserow. – *Die selbe Landschaft in der Sahelzone nahe Mainé-Soroa, Süd-Ost Niger, 31. März 2010*

coordinates). Optional additional information includes number observed, evidence of breeding, and any other remarks thought useful, e. g. comments on interaction with other birds or with the local vegetation. If there are any images available of the birds observed, these can be attached to the relevant records. Uploading can take place after logging in, using drop-down menus that appear when four or more consecutive letters from anywhere within a species or location name have been typed in. Batch uploading of records in an Excel file is also possible, with the assistance of one of the administrators.

Anyone interested can extract information from the WABDaB on-line for all countries at the same time or only for (at present) Burkina Faso or Chad or Niger. Only the precise coordinates of observations are privileged information, though relevant national ministries have access to that information as well. For information to be used for commercial purposes, a fee must be negotiated with the WABDaB administrators. The following can be extracted:

- records per species, per location or per area such as a national park (the latter only through the administrators); if desired only breeding records can be selected
- images per species, per location or per photographer
- block maps per species, based on all records, on records from each of the four seasons (Dec-Feb, Mar-May, Jun-Aug, Sep-Nov), or only on records from a particular time of year (months A-X) and/or from a particular period of years (19xx-19yy or 20yy); as reference background one can choose colouring that indicates how many records the WABDaB contains from the same block and period, or how many species were observed in the same block during the same period
- precise location maps for a particular species (only via the administrators)
- information per contributor, including all records, a list of species observed (and a list of species not yet observed), and all photos

As of 25th August 2016 the WABDaB contained 67,812 records of 540 species from 375 half-degree blocks, including breeding evidence for 216 species. It also included 3,126 photos of 392 species. The WABDaB also has available for downloading:

- terms of use
- checklists of all species known from West Africa as a whole or from Burkina Faso, Chad or Niger separately, with an indication of whether there are already any records and pictures of that species for the region or country in the WABDaB; and with links to the individual species pages that contain the overall map of the species distribution based on all the records in the WABDaB, an overview of all the records held, and all the photos.
- a list of relevant ornithological publications, a number of them with a link to the pdf
- and documents on how to separate certain difficult species pairs, e. g. Black Kite *Milvus migrans migrans* and Yellow-billed Kite *M. aegyptius parasitus*, the pale forms of Booted Eagle *Hieraaetus pennatus* and Wahlberg's Eagle *H. wahlbergi*, and Saville's Bustard *Lophotis savilei* and Black-bellied Bustard *Lissotis melanogaster*.

3. Connecting with local people: ethno-ornithological information available in the WABDaB

To better connect with local people the WABDaB includes information on names of birds in local languages, as well as stories about birds in local cultures. People with no interest in birds often do have an interest in their own culture. Showing that birds are part of that culture can make them realise that if they want to conserve that culture, they should also help conserve birds. In addition, this kind of information is getting lost and deserves preservation in its own right. As migration increases and televisions running on solar panels appear in even the remotest villages, there is less passing on of this cultural heritage to the next generation.

Information on local bird names in the WABDaB includes the scientific, French and English names; the local language involved; the locality where the name comes from; the name and its literal translation; any local lore attached to the name; the name, year of birth and position or function of the source for the name; and the name of the collector and year of collection. For instance, Montagu's Harrier *Circus pygargus* is called by the Zjerma of SW Niger 'gébia felle', 'the bird that dances (like the women swaying with their cloth back and forth)'. A name that will need no explanation to those who have seen Montagu's Harriers quartering a field, looking for prey. And the Zjerma name for the Sahel Paradise Whydah *Vidua orientalis* is ' Nia néré ka ta sounfey', meaning 'selling one's mother to get one's tail back'. This most likely refers to the fact that male Sahel Paradise Whydahs in eclipse look like females, and that after they have moulted into breeding plumage with a long tail there all of a sudden seem to be less females.

Information on bird stories in local cultures in the WABDaB includes stories from the Gourmantché in the area of the border between Burkina Faso and Niger on how the Cattle Egret *Bubulcus ibis* came to be white; how the Hooded Vulture *Necrosyrtes monachus* lost the feathers on its head; and how the Pied Crow *Corvus albus* got those white markings. One story not included on the website concerns the wisdom of the Hoopoe *Upupa epops*. The Zjerma in SW Niger say that this bird is so smart that when it takes off, before it lands again it has read the whole Koran. This probably refers to the fact that the wings of the Hoopoe, with their black and white bands, look like black writing on a white background, such as Koran scrolls. You role up or fold away those scrolls when you've finished reading them.

The local lore continues by saying that, if you want your children to become just as smart as the Hoopoe, you just must take a dried Hoopoe head, grind it up, and mix the resulting powder through your child's food. Not a practice most conservationists will want to encourage!

4. Utilisation to date of information from the WABDaB

Information from the WABDaB has been used to help e. g.:

- improve and update maps in the field guide for West Africa by Borrow & Demey (2014)
- assess the Africa-wide conservation status of vultures (Ogada & Buij 2011), Secretarybird *Sagittarius serpentarius* (Baker *et al.* 2010) and parrots (Martin *et al.* 2014)
- formulate species action plans for Spoonbill *Platalea leucorodea* (Triplet *et al.* 2008) and Turtledove *Streptopelia turtur* (Fisher *et al.* in prep.)
- assess the status of terrestrial and freshwater fauna in West and Central Africa by IUCN (Mallon *et al.* 2015)
- and assess the effects of climate change on bird distribution in a project of BirdLife International.

In addition, images uploaded to the WABDaB have raised a number of taxonomical questions. These are being worked on at present.

5. Plans for the future

Of the countries presently covered in the WABDaB, we would especially like to improve the information from Burkina Faso, which we have as yet hardly touched on. Extending the WABDaB to other countries in the region is an option, the programming has already been adapted for that. But to do so, more resources are needed, both people and money.

At present the WABDaB contains mostly records from the past 25 years. We would also like to include all known historical records from the literature, so that it is possible to check for changes in distributions.

In addition, we would like to include visual information from bird band recoveries, geolocator studies, and satellite-tracking studies. Such information can help people in Africa and in Europe realise that migratory birds are a shared heritage and that we must all collaborate to ensure their conservation. Bird bands, geolocators and satellite transmitters have already shown Niger to be connected to 93 other countries, including almost all African and European countries, as far west as Iceland/Greenland/eastern Canada (Northern Wheatear *Oenanthe oenanthe leucorhoa*) and as far east as eastern Russia and Kazakhstan (Pallid Harrier *Circus macrourus*) (unpublished data).

Acknowledgements: Our sincere thanks go to all who have contributed records or photos to the WABDaB, and we hope will do so in the future. Without them the WABDaB would not be half the resource it is now. They are too many to name individually, but we feel we should make an exception for the Sahara Conservation Fund, who have provided almost all the records from central Chad and from east-central Niger. Tim Wacher of the Sahara Conservation Fund and the Zoological Society London is the WABDaB's co-country administrator for Chad. Our thanks also go to David Kusserow for his striking images of the same landscape in the Sahel at different times of the year, and to an anonymous referee for helpful comments on an earlier version of this contribution.

6. Zusammenfassung

Liedén, U. & J. Brouwer 2017: Die „West African Bird DataBase" – ein Naturschutzwerkzeug auch für innerafrikanische und paläarktische Zugvögel. Vogelwelt 137: 201–205.

Viele Brutvögel der Paläarktis verbringen den Winter auf der Nordhalbkugel im südlich der Sahara gelegenen Afrika (Subsahara-Afrika, SSA), einer riesigen Region mit sehr wenigen Ornithologen, die darüber hinaus eine Vielzahl von Standvögeln und innerafrikanischen Zugvögeln beherbergt. Die vorherrschende Landnutzung und Landnutzungsänderungen im SSA werden in erster Linie durch die lokale Bevölkerung und weniger durch nationale Regierungen festgelegt. Ein effektiver Vogelschutz kann nur unter Einbeziehung der lokalen Bevölkerung erfolgen, und größere Anstrengung und mehr Finanzmittel aus Europa für Schutzmaßnahmen in Afrika sind dringend erforderlich. Die westafrikanische Vogeldatenbank (WABDaB) www.wabdab.org ist ein Werkzeug zum Schutze aller Vogelarten Westafrikas. Die Datenbank ist online, frei zugänglich, zweisprachig (französisch und englisch) und umfasst seit 1. September 2016 Niger, Tschad und Burkina Faso. Sowohl aktuelle als auch historische Vogelbeobachtungen können, ebenso wie verfügbare Fotografien, hochgeladen werden. Beobachtungen und/oder Karten können aus der Datenbank extrahiert werden, indem Abfragen über Vogelart, geografische Einheit, Zeitraum (Jahreszeit und definierte Anzahl von Jahren) und Beobachter definiert werden. Relevante nationale Ministerien haben vollständigen Zugang zu den gesammelten Daten. Bei einer Nutzung für kommerzielle Zwecke hingegen wird eine Gebühr erhoben. Die Webseite enthält zudem nationale Checklisten für Vogelarten, eine Auflistung relevanter Literatur und Bestimmungshilfen für schwierig zu unterscheidende Vogelarten. Um die lokale Bevölkerung verstärkt einzubeziehen, werden zudem Vogelnamen und Vogelgeschichten in den lokalen Sprachen und

Kulturen gesammelt, da durch gesellschaftliche Veränderungen die Gefahr besteht, dass solches lokales Wissen verschwindet. Zukunftsideen für WABDaB sind die Visualisierung der Ergebnisse von Zugvogelstudien, die z. B. zeigen, dass das Land Niger durch Zugvögel mit wenigstens 93 anderen Staaten verbunden ist. Darunter finden sich nahezu alle Staaten Afrikas, Europas und des Nahen Ostens ebenso wie Nord-Ost Kanada/Grönland /Island, der Osten Russlands und Kasachstan.

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WABDaB.org
:: West African Bird DataBase ::

Preparations of young White Storks *Ciconia ciconia* for migration flight

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The preparation for flight by White Storks from being fully fledged to the first days of migration was analyzed by using position and velocity data of 31 young White Storks preparing for first migration, equipped with GPS logger tags. The effects of body mass, weather and social factors on the frequency and duration of flight exercises until the start of migration were examined. Presenting a number of particular cases, we show that birds use environmental and social cues when preparing for their first migration. Such, birds stop-over or even return distances of up to 70 km to join later leaving groups of birds. We also observed a bird that switched from the eastern to the western migration route when weather conditions worsened considerably. In addition, we observed that activity during the post-fledging period is correlated to body mass. We observed that juveniles extend their home range prior to migration.

Keywords: White Stork *Ciconia ciconia*, migration, GPS logger, home range

1. Introduction

Storks on migration have particular flight strategies, depending on environmental conditions (Leshem & Yom-Tov 1996, Shamoun-Baranes *et al.* 2010). In this paper we focus on young unexperienced birds that have to learn such strategies. We show that learning starts already during the post-fledging period and continues during the birds' first migration.

To examine the learning flights of first-time migrants we used measurements of the animal's position data, as well as velocity and acceleration.

2. Materials and Methods

We analyzed GPS data of 31 White Storks originating from North-West-Germany, from places close to Loburg (52° 7' N 12° 4' E, known in German as "village of the storks"). We correlated the data sets from Movebank (Wikelski & Kays 2014) of the various birds to each other, to find indicators of social behavior, and to weather data, for the impact of meteorological conditions. Looking at the birds' velocities and distances from the nest in the days prior to migration, we searched for patterns that might signal the day of departure for autumn migration. Knowing the date of departure in advance is important for programming GPS logger tags more efficiently, since it would be possible to restrict the data collection to velocities above a certain threshold value only, once migration has started, and thus to save battery power and memory.

The 31 young birds whose data we study were all equipped with lightweight electronic observation tags which allow registering and storing GPS data, such as the bird's position and velocity (GPS-ACC-logger tags, produced by e-obs, digital telemetry, and described in the handbook "New generation of BaseStation b5 and GPS-ACC-Logger-Tags" (E-obs GmbH 2010)). Such miniature sensors do not affect the birds' behavior (von Huenerbein *et al.* 2000, Yoda *et al.* 1999). When the tag was placed, the birds were ringed, and further parameters describing the physical condition of the bird were taken. With the observation tags used in 2013, data could be downloaded and storage place freed only when birds were in a vicinity of not more than 15 km to the downloading device. This meant that data of two birds that died during the time period of the study could be downloaded only because one individual died close to the field station, and the other one was found dead and returned to the research group. The tracks of another two birds were completely lost, for unknown reasons.

The migration paths of the birds of our study can be viewed on "Movebank" (Wikelski & Kays 2014), choosing the tab "Tracking data map" and the data set "LifeTrack White Stork Loburg".

Measured GPS speeds were estimated from ground speeds between consecutive locations. We interpreted all registered events of speeds of 5 m/s or more as flight activity (active or passive flight). Since the power curve of storks increases steeply for speeds falling below this limit, it is unlikely that birds will sustain lower speeds during flight, especially juveniles who are not yet expert flyers. (The power curve shows drag versus speed and reveals that at too low speeds more rather than less thrust is required to maintain speed. Birds would usually not fly at these too low speeds.)

Not all data of all birds were taken with the same frequency. The frequency of position and velocity data taken in the months of July and August 2013 varied from 1 Hz to 1/300 Hz. Therefore, we used for further analysis the ratio of flight events to all events registered on the same day.

Looking for patterns in training we extracted and calculated for each of the 31 tagged storks the following numerical

Table 1: Number and frequency of days with recorded flight prior to migration. – *Anzahl und relative Häufigkeit von Flugtagen vor Zugbeginn.*

n=25	Number of days between first flight and start of migration – *Anzahl der Tage zwischen erstem Flug und Start des Wegzugs*	Number of days on which flying was registered – *Anzahl der Tage mit Flugbewegungen*	Flight frequency – *Flughäufigkeit*
Maximum	41	26	1.00
Minimum	11	8	0.27
Average – *Mittelwert*	24	16	0.70
Standard deviation – *Standardabweichung*	8	4	0.19

indicators using Matlab (The MathWorks Inc. 2014):

- the first day of flight activity,
- the date of start of migration,
- the time span in days between the first day of flight activity and start of migration,
- the total number of training days (i.e. the number of days on which flight was registered at least once). Since most of the birds rested on some days, the total number of training days is not equal to the time span between the start of flight training and the start of migration.

Therefore, we also determined:

- flight frequency, which is the total number of flight days divided by the number of days between the first day of flight training and the start of migration.

In addition, we used geolocation to calculate to which degree birds explored their environment on the days before departure, i.e. we calculated for the days prior to migration the maximum distance reached (in km) from the previous overnight place and the corresponding azimuth.

Not all young birds start full migration immediately. Some moved not further than to South Germany, others moved ~ 30-50 km south-east, waited a few days and then continued migration with a group of birds that had left on a later date. We define as "start of migration" the day on which the geolocation of the subsequent night was for the first time at least 20 km away from the geolocation of the preceding night and after which birds did not return to their home places (breeding area).

To check correlations with climate conditions we used data of the nearest weather station to Loburg, which is Wiesenburg, Germany (WMO10368), situated about 26 km away from Loburg. The data we got from this station are temperature (°C), wind speed (km/h), wind direction, pressure (mbar) and humidity. The weather conditions enroute were obtained from the nearest weather station to each measured location.

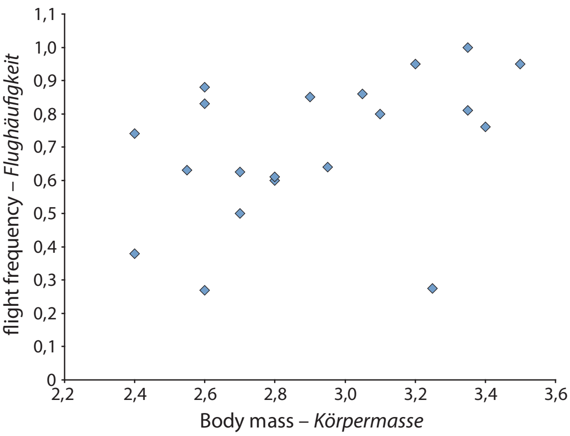


Fig. 1: Relationship between flight frequency and body mass. Each bird is represented by one data point. – *Beziehung zwischen relativer Flughäufigkeit und Körpermasse. Jeder Vogel wird durch einen Datenpunkt dargestellt.*

3. Results

3.1 The impact of body mass on flight patterns

25 of the 31 young storks of this study started migration in August (23) or early September 2013 (2). 22 of these birds were traced for a considerable distance on the eastern route to Africa (at least up to Romania), one migrated to Spain, and two remained in Germany, but not in the same place. The other six birds either died (2), remained in the same place (2), or their track was lost (2). An enormous variability characterizes the parameters that describe flight behavior in the days prior to migration: The 25 birds that started migration started flying between 41 and 11 days before the start of migration. Table 1 shows the big individual differences in flight activity before the start of migration and in the flight frequency (the number of flight days divided by the time span in days from the first day of flight to the start of migration).

Flight activity was slightly related to body mass. Stronger birds flew more frequently than smaller birds: seven out of nine birds that weighed more than 3 kg when they were ringed in July, flew on three out of four days at least, i.e. they flew with a frequency of 0.75 at least. They successfully started migration to Africa and where traced at least up to Rumania. One bird died in a field before it started flying, and another one flew much less frequently, but still reached Lebanon, where it was hunted and killed.

Only three of the 15 birds that weighed *less than* 3 kg by the time they were ringed in July flew frequently ($f \leq 0.75$), nine flew less frequently, three flew sporadically or not at all and did not start migration (one of these three died). These observations are illustrated in Fig. 1.

Table 2: Occurrence of first and second flight events. Birds that started flying together are grouped together, starting with the strongest bird. In all groups, smaller birds take a longer break until the second flight event. – *Kalenderdaten der ersten und zweiten Flugereignisse. Vögel, die gemeinsam flogen, werden als Gruppe gelistet, beginnend mit dem kräftigsten Vogel. In allen Gruppen brauchen die kleineren Vögel eine längere Pause bis zum zweiten Flugereignis.*

Download Number – *Download Nummer*	Body mass in kg – *Körpergewicht in kg*	First flight event – *erstes Flugereignis*	Second flight event – *zweites Flugereignis*	Number of days until second flight event – *Anzahl der Tage bis zum zweites Flugereignis*
10792930	3.5	16/07/2013	18/07/2013	2
10792939	2.8	16/07/2013	26/07/2013	10
10792934	3.25	17/07/2013	20/07/2013	3
10792918	2.7	17/07/2013	23/07/2013	6
10792931	2.4	17/07/2013	21/07/2013	4
10792929	3.4	22/07/2013	27/07/2013	5
10792925	2.8	22/07/2013	01/08/2013	10
10792936	3.35	27/07/2013	28/07/2013	1
10792927	2.7	27/07/2013	05/08/2013	9
10792926	3.05	29/07/2013	30/07/2013	1
10792932	2.3	29/07/2013	02/08/2013	4
10792924	2.55	29/07/2013	(died – *gestorben*)	

3.2 The impact of social factors

The birds of our study stem from neighboring nesting areas. We consider them as "flying together" when their geolocations deferred in less than 0.1° and when they headed towards the same direction during the same hours.

In seven cases of the nine less frequently flying smaller birds, first flying occurred together with first flying of stronger birds. Later flight events of these birds occurred with a much larger delay (see Table 2).

This observation suggests that smaller birds might have been triggered by larger birds to start flying, and might have been in need of a break afterwards.

The fact that there were days when groups of birds started flying and that there were days with a high total of flight events as reported in Table 3 leads to the question whether particular climate conditions trigger flying. This is examined in the following section.

As is well known, White Storks usually start migration in groups (Newton 2007). The 25 birds of this study that started migration left on 10 different dates. As can be seen in Table 3, the largest groups of birds left on 20th August.

The bird with ring number HL442-3036, whose GPS data carry the download number 10792919, is remarkable. This bird left with the group leaving on 16th August, turned at 13:00 at Magdeburg (after ~70 km) without rest backwards, and started migration with the group that left North Germany on 20th August. The body mass of this bird was 2.6 kg on 15th July 2013. It was a rather small bird in the group of birds ringed in July and flew frequently (on 83 % of the days between starting to training and the start of migration). Other birds leaving on 16th August travelled 95 – 105 km on their first day of migration, i.e. about 40 % farther (see Table 4).

The two birds with the ring numbers 446-3044 (from Drömling) and 746-2950 (from Elsnigk, 51.80°N, 12.07°E) were similar in their behavior: Bird 446-3044 migrated on 12th August 32 km south-east and continued migration with the group of birds leaving on 20th August. After having joined the group, it travelled 202 km on 20th August.

Bird 746-2950 migrated 20 km south on the 26th August and then joined a group of birds on the 28th August with which it continued 140 km south-east on the same day.

3.3 The impact of meteorological conditions

Looking at the number of birds that were flying on a specific day and looking at the total of flying events, we found two peaks in July: on the 21st and on the 26th of the month. These days were particularly hot and windless compared to the preceding days. Apparently these conditions are favorable for young birds whose wing area – body volume ratio is larger than for adult birds (Nachtigall 1985).

Table 3: Migration start dates and numbers of birds leaving on these days. – *Kalenderdaten des Zugbeginns und die Anzahl der jeweils abfliegenden Vögel.*

Date – *Datum*	05/08	09/08	12/08	16/08	18/08	20/08	26/08	28/08	01/09	07/09
Number of birds leaving – *Anzahl der abziehenden Vögel*	1	1	2	4	1	8	2	4	1	1

Table 4: Geolocations of selected birds on selected days. Highlighted in red are the geolocations of a bird that turned northwards after a first migration attempt, to join a group of birds that left four days later (highlighted in green). – *Positionsdaten ausgewählter Vögel an ausgewählten Daten. Rot markiert sind die Postionsdaten eines Vogels, der nach einem ersten Migrationsversuch wieder nordwärts flog, um sich einer vier Tage später abfliegenden Gruppe anzuschließen (grün markiert).*

Download Number – *Download Nummer*	Lat. on 16/08, 8:00	Lon. on 16/08, 8:00	Lat. on 16/08, 13:00	Lon. on 16/08, 13:00	Lat. on 20/08, 8:00	Lon. on 20/08, 8:00	Lat. on 20/08, 14:00	Lon. on 20/08, 14:00
10792929	52.511	11.075	52.020	11.842	48.279	21.293	46.744	22.334
10792923	52.480	11.238	52.020	11.842	48.278	21.294	46.742	22.334
10792925	52.481	11.258	52.020	11.843	51.661	12.128	51.664	12.135
10792939	52.514	11.078	52.019	11.843	51.661	12.127	51.091	13.930
10792919	52.547	10.943	52.101	11.665	52.438	11.281	51.398	13.548
10792920	52.426	11.284	52.425	11.288	52.438	11.279	51.398	13.547
10792918	52.446	11.230	52.439	11.222	52.435	11.277	51.400	13.550
10792931	52.446	11.229	52.444	11.228	52.431	11.283	51.399	13.549
10792926	52.510	11.075	52.494	11.052	52.502	11.075	51.191	13.429
10792916	52.112	12.083	52.116	12.083	52.117	12.084	51.288	13.745
10792928	52.115	12.085	52.115	12.083	52.115	12.088	51.287	13.732
10792927	52.114	12.084	52.116	12.083	52.116	12.089	51.287	13.732

The behavior of bird number 473-2760 (GPS download number 11089902) seems highly correlated to changing weather conditions.

This individual was a late juvenile that weighed 3.15 kg when it was tagged on 2nd August 2013. It started migration on 28th August. Within three days it arrived to the Czech Republic. On 31st August and on 1st September it stayed in the same place (49.15 N, 17.12 E), turned north-west and continued to France where it got electrocuted on power lines (Fig. 3).

This bird was the last one of the birds of our study that left on the eastern route. Juveniles that started migration even later remained in South Germany; one of them went to Spain.

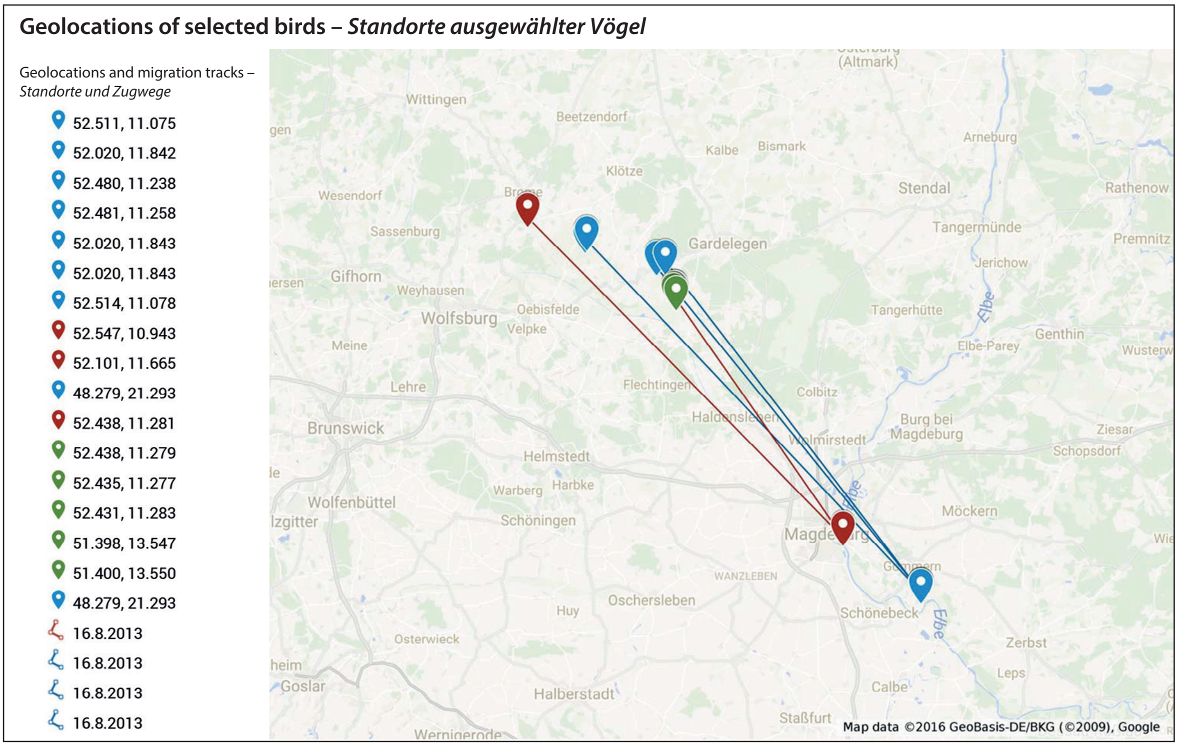


Fig. 2: This map illustrates part of the data of Table 4. The bird with the tag number 10792919, whose position data are indicated in red, moved on the same day as birds whose position data are indicated in blue, but turned back northwards to join four days later the birds whose position data are indicated in green. Colors match the colors in Table 4. – *Diese Karte zeigt einen Teil der in Tabelle 4 aufgelisteten Positionsdaten. Der Vogel mit der Tag-Nummer 10792919, dessen Route rot gezeichnet ist, flog zurück, um sich einer vier Tage später abfliegenden Gruppe anzuschließen (deren Positionsdaten grün gekennzeichnet sind). Die Farben entsprechen denjenigen in Tabelle 4.*

Fig. 3: The route of a bird changing direction in the Czech Republic due to bad weather conditions. The map was generated with Mathematica10 (Wolfram Research Inc. 2015). – *Die Route eines Vogels, der über Tschechien die östliche Route verließ und Richtung Westen flog. Die Karte wurde mit Mathematica10 erzeugt (Wolfram Research Inc. 2015).*

All other birds travelling on the eastern route except for one passed the same latitude (49.15° N) further in the east and the same longitude (17.12° E) further in the south.

From 31st August to the 1st September in the place where the bird with ring number 473-2760 changed route the temperature dropped from 23.5 °C at 13:00 on 31st August to 18.5 °C at the same hour on 1st September, wind direction changed by about 150° to coming from the north and wind speed increased (Fig. 4-6). While the maximum wind speed on 30th August was 14.4 km/h at 16:00, it was 27.72 km/h on 1st September at 15:30. All data are from the weather station in Kunovice in the Czech Republic, which is about 27 km away from the position of the bird.

At the same weather station rainfall was checked at 30 min intervals. In the night of 30th August rainfall was registered only once at midnight, on the 31st twice (at 14:00 and at 15:00) and on 1st September continuously from 4:00 in the morning to 9:00, and then again at 10:00 and at 12:00.

Summarizing, the bird changed route when weather conditions worsened considerably.

3.4 Leaving the home range before the start of migration

Looking at the daily maximum distances reached when exploring the environment, juvenile birds extend their range prior to migration. The natal home range of the White Stork is usually not larger than 1.5 km (Dziewiaty 1992, Ożgo & Bogucki 1999, Nowakowski 2003). Values of up to 2.5 km are reported in suboptimal environments only (Struwe & Thomsen

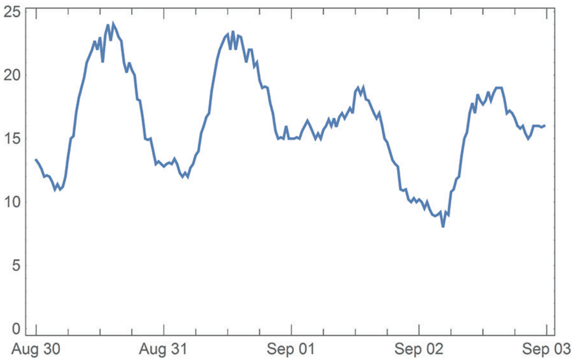


Fig. 4: Temperatures (in °C) measured at the weather station of Kunovice in the Czech Republic, 2013. – *Temperaturmessungen (in °C) von der Wetterstation Kunoviche in Tschechien, 2013.*

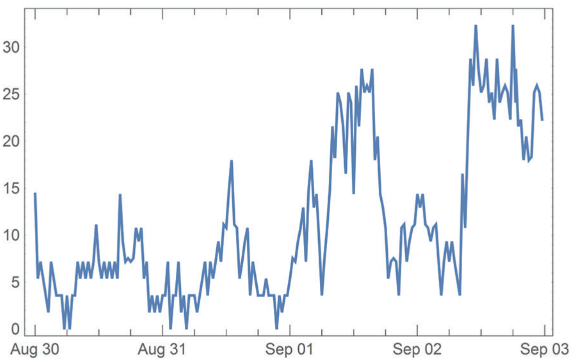


Fig. 5: Wind speed (in km/h) measured at the weather station of Kunovice in the Czech Republic, 2013. – *Windgeschwindigkeiten (in km/h) nach Messungen der Wetterstation von Kunoviche in Tschechien, 2013.*

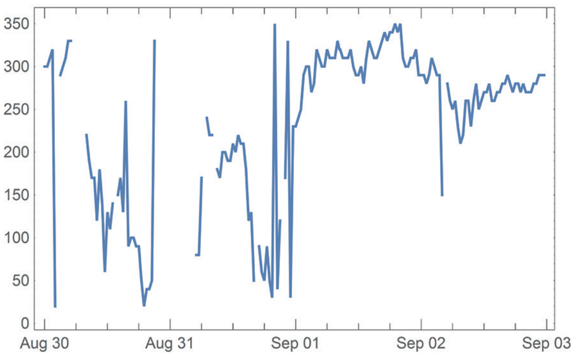


Fig. 6: Wind direction (in azimuth degrees) measured at the weather station of Kunovice in the Czech Republic, 2013. – *Windrichtungen nach Messungen der Wetterstation in Kunoviche, Tschechien, 2013.*

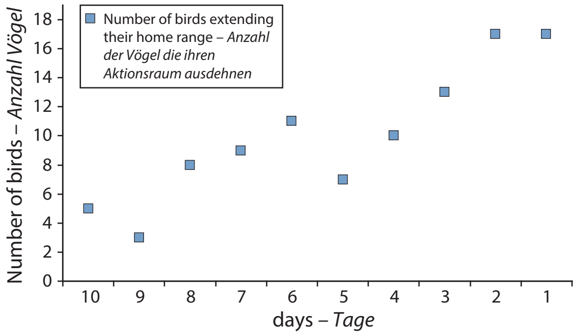


Fig. 7: Number of birds (n) increasing their home range (1.5 km) on the days prior to migration. – *Anzahl der Vögel (n), die ihren Aktionsraum ausdehnten, in den Tagen vor Zugbeginn.*

1991). Fig. 7 shows the number of young birds that increased their home range on the days prior to migration. The size of the group was n=25.

On the day before migration, 72 % of the tagged juveniles exceeded the 1.5 km range. In addition, we observed that some other, not yet migrating, birds extended their range when others left for migration: on 5th August one tagged bird left for migration, but no other bird went away for more than 1.5 km. On the following day, 6th August, five birds went away for more than 1.5 km. Directions are usually scattered. To determine directions, we calculated the azimuth of the farthest point reached with respect to the last overnight place.

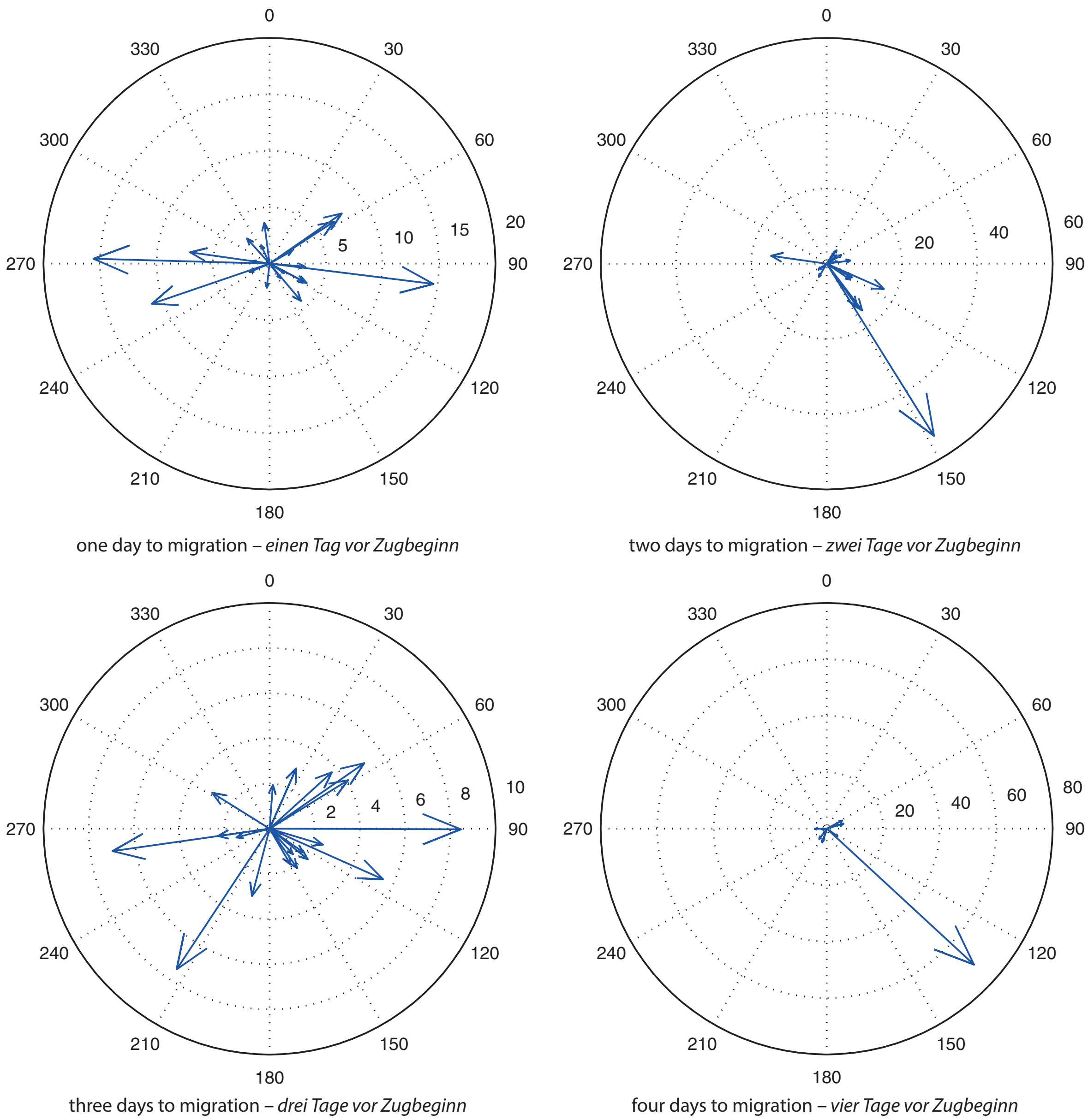


Fig. 8: Directions chosen by birds leaving their natal home range on the last four days prior to migration. Numbers along the concentric circles indicate distance in km. – *Die von Vögeln, die ihren Aktionsraum ausdehnen, bevorzugten Richtungen. Die Zahlen entlang der konzentrischen Kreise geben Entfernungen in km wieder.*

Directions of exploring the environment are rather scattered on the days prior to migration. Individual birds went far to the south-east (Fig. 8 and 9).

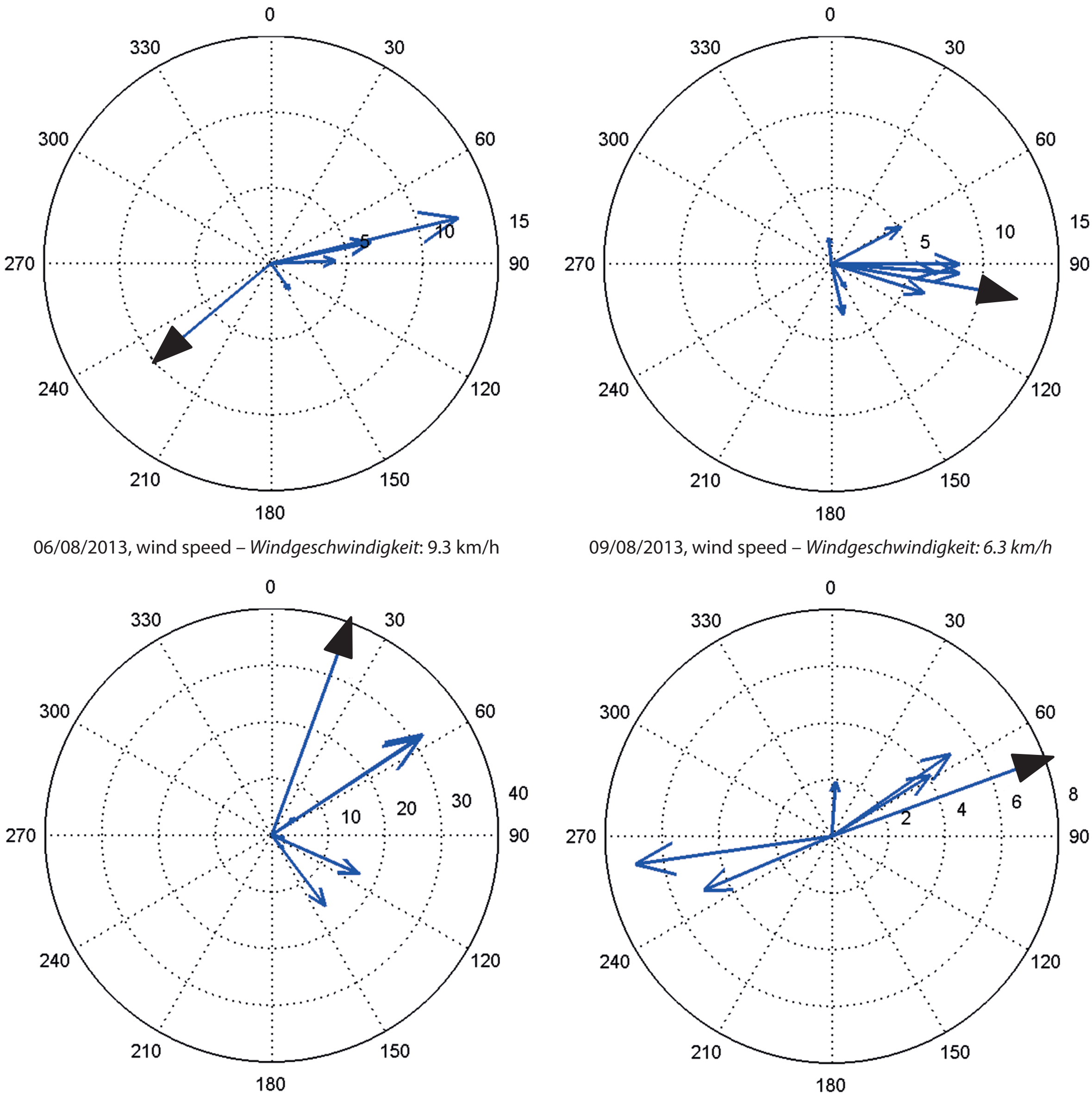
Looking at fixed calendar days, there were a few days with preferred directions, but we were not able to establish any correlation with wind directions.

4. Discussion

The purpose of this study was to study flight patterns of young storks in the days prior to migration until the first days of migration, using tag GPS data, with the aim to find evidence for the impact of social and meteorological factors and to perhaps find clues that indicate the date of start of migration.

Looking at individual birds, we were able to show that birds can use social and weather clues when starting to train or to migrate as there are more flight events on hotter days, and a bird that changed direction due to worsening weather conditions.

Looking at data of young storks only, we were not able to predict the start of migration, even though we were looking for correlations with meteorological data. The missing link is probably data of adult storks. Looking at the limited amount of data we have, there is strong evidence for an impact of social factors. We need data of



06/08/2013, wind speed – *Windgeschwindigkeit*: 9.3 km/h

09/08/2013, wind speed – *Windgeschwindigkeit: 6.3 km/h*

10/08/2013, wind speed – *Windgeschwindigkeit: 9.3km/h*

13/08/2013, wind speed – *Windgeschwindigkeit: 15.6 km/h*

Fig. 9: Directions chosen by birds leaving their home range on specific calendar days. The black-headed arrows indicate the prevailing wind direction. – *Die von Vögeln, die ihren Aktionsraum ausdehnen, bevorzugten Richtungen an ausgewählten Kalendertagen. Die mit schwarzen Spitzen gekennzeichneten Pfeile geben die vorherrschende Windrichtung an.*

adult and young birds to see what triggers the departure of adult storks and if young storks follow them. It will take another few years to collect geolocation and velocity data of adult and young storks originating from the same region, since the loss of tags is high. The current study was started with 31 birds. Only in one case we have data of a bird's second year autumn migration.

Evidence for the impact of social factors showed a bird that started migration with a group of four tagged young birds (and probably other birds that were not tagged), migrated ~70 km to the SW, returned home and joined another group of birds that left four days later.

We saw evidence for the impact of meteorological conditions in the case of one bird whose GPS data reveal that this bird moved eastwards, and turned westwards when weather conditions got hard. Chernetsov *et al.* (2004) report a similar abrupt change in direction in Germany of a young white stork that was satellite-tracked and eventually found dead in Greece. In their case, adult storks accompanying the young stork were observed. Therefore, the authors conclude that the young stork changed direction for social reasons, to join adult storks. In our case we do not know if there were additional social reasons, since we do not have data of accompanying adult storks.

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5. Zusammenfassung

Stöcker-Segre, S. & D. Weihs 2017: Zugvorbereitungen junger Weißstörche *Ciconia ciconia*. Vogelwelt 137: 206–214.

Positions- und Geschwindigkeitsdaten junger Weißstörche, die im Zeitraum vom Verlassen des Nestes bis zu den ersten Zugtagen erhoben wurden, geben Aufschluss darüber, wie sich junge Weißstörche auf ihren ersten Zug in den Süden vorbereiten. Zu diesem Zweck wurden die Daten von 31 Jungstörchen, die mit GPS-Sensoren ausgestattet waren, ausgewertet. Insbesondere wurde der Einfluss der Körpermasse, sowie der Einfluss von sozialen Faktoren und meteorologischen Bedingungen auf das Flugverhalten vor und während der ersten Zugtage untersucht. Alle Jungvögel stammten aus der Umgebung von Loburg (52° 7‘ N 12° 4‘ E, auch als „Storchendorf" bekannt). Wir zeigen, dass das Flugverhalten der Jungvögel von meteorologischen Gegebenheiten und von sozialen Faktoren beeinflusst wird: Jungvögel unterbrechen den Flug in den Süden oder fliegen bis zu 70 km zurück in Richtung des Brutgebietes, um sich später fliegenden Gruppen anzuschließen. Ein junger Weißstorch konnte beobachten werden, der über Tschechien von der östlichen auf die westliche Flugroute wechselte, als sich die Wetterbedingungen drastisch verschlechterten. Des Weiteren konnte beobachtet werden, dass die Jungvögel ihren Aktionsraum in zunehmendem Maße in den Tagen vor Zugbeginn ausdehnen.

Die ersten Zugtage wurden in dieser Studie über Zugvorbereitung mit aufgenommen, da sich der Zugbeginn nicht immer genau abgrenzen lässt. Einige Vögel überwinterten in Süddeutschland oder Osteuropa, andere kehrten, wie oben erwähnt, nach bis zu 70 km noch einmal in Richtung Brutgebiet zurück, um sich einer späteren abfliegenden Gruppe anzuschließen. Insgesamt zeigt die Datenauswertung sehr individuelles Verhalten bei der Flugvorbereitung und erweist sich als schwierig, solange nur wenige Altvögel mit GPS-Sensoren ausgestattet sind, da Altvögel das Verhalten der Jungvögel mitbestimmen.

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Developing a forest bird indicator for Austria

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Teufelbauer, N., R. Büchsenmeister, A. Berger, B.S. Seaman, B. Regner, E. Nemeth & S.J. Butler 2017: Developing a forest bird indicator for Austria. Vogelwelt 137: 215–224.

Multi-species indicators combining the population trends of bird species, e.g. for a given habitat, are a valuable tool for bird conservation. A smart selection of the indicator species allows such indicators to provide a good summary of the changes occurring in the bird community as a whole in that habitat. In this paper we report on the development of a forest bird indicator for Austria, designed to act as a proxy for the population development of forest bird species overall. For the selection of indicator species we used an objective, niche-based approach following two simple rules: (1) all resources used by birds in forests should be covered by the indicator species set, and (2) the species selected should be as specialised as possible. This approach was developed by Wade *et al.* (2014) on a European scale, and our work constitutes its first-time application to the forest bird community at a single-country level. The indicator species set was selected from a list of all Austrian forest species with at least 200 breeding pairs and was shown to be ideally composed of 26 bird species. As yearly population trend data is currently not available for some of these species, we re-ran the selection procedure, restricting selection to species for which trend data is available from the Austrian common bird monitoring scheme. This resulted in two equally suited indicator species sets, each composed of 19 species and differing from the other in only one species. The trends of these indicator species sets from 1998-2012 did not differ significantly from one another, nor from the trend calculated for the full list of forest species for which data was available – a moderate decline in all cases, ranging from -1.13 %/year to -1.30 %/year. The indicator species finally selected were Stock Dove, Cuckoo, Black Woodpecker, Great Spotted Woodpecker, Wren, Robin, Nightingale, Blackbird, Western Bonelli's Warbler, Wood Warbler, Goldcrest, Firecrest, Collared Flycatcher, Marsh Tit, Crested Tit, Golden Oriole, Jay, Crossbill, and, interchangeably, Willow Warbler or Coal Tit.

Keywords: forest bird indicator, Austria, multi-species indicator, trends

1. Introduction

In the last decades common bird monitoring schemes (CMBS) have evolved in many countries in Europe (overview in European Bird Census Council 2016) as well as in North America (e.g. Sauer *et al.* 2014). These schemes are predominantly based on the counts of volunteer observers, an approach that has a long and successful history especially in bird conservation (see Greenwood 2007). CBMS enable the calculation of yearly population changes for a wide range of common and widely distributed bird species (e.g. Teufelbauer & Seaman 2016 for Austria). Beside single species trends, the wealth and quality of available data stimulated the development of multi-species indicators (see Ter Braak *et al.* 1994, Gibbons 2000, van Strien *et al.* 2001 and 2004, Gregory *et al.* 2003, 2005 and 2008). These summarise the changes of bird communities and act as state-indicators (Gregory *et al.* 2005). They are aimed at generalising complex information and thus providing simple, immediate information to policy-makers and the general public (Gregory *et al.* 2008). Such indicators usually stand for habitat categories like farmland or forest (e.g. Gregory *et al.* 2003, Achtziger *et al.* 2004, Zbinden *et al.* 2005, Szép *et al.* 2012, Eskildsen *et al.* 2013), but multi-species indicators have also been composed for montane areas (Lehikoinen *et al.* 2014) or for measuring the impact of climatic change (Gregory *et al.* 2009, Stephens *et al.* 2016). Furthermore, multi-species indicators have not only been developed for individual countries (see aforementioned references as examples), but also for larger regions and the whole of Europe (Gregory *et al.* 2007, Gregory *et al.* 2008, European Bird Census Council 2016).

Following the requirements of the European Commission, an indicator for farmland birds – the Farmland Bird Index (FBI) – has been established in Austria (Teufelbauer & Frühauf 2010). The FBI is used by the European Commission as a proxy for biodiversity in farmed habitats (Directorate General for Agriculture and Rural Development 2006) and is used to evaluate measures implemented under the Rural Development Program 2007-2013 [Regulation (EC) No 1974/2006] as well as in the new Program

[Regulation (EU) No 1306/2013]. However, for other habitats in Austria analogous indicators are missing. Forests cover 3.99 million hectares or 47.6 % of Austria (Russ 2011) and are therefore of major importance for bird species. In this study, we report on the set-up of a multi-species bird indicator for Austrian forests. It was our aim to build an indicator in which the population trends of selected bird species stand as a proxy for the development of the whole community of bird species living in Austrian forests. We name this indicator 'Woodland Bird Index' (abbreviated 'WBI'), rather than using the better-fitting denomination 'Forest Bird Index', to enable an easy discrimination between this indicator and the Farmland Bird Index, which would have the identical acronym FBI.

A crucial part of the set-up of the WBI, as for any other indicator of this kind, is the selection of the indicator species. For existing multi-species indicators various approaches have been used, e. g. using existing knowledge on species' biology, often combined with expert judgement and the availability of trend data (e. g. Achtziger *et al.* 2003, 2004, Gregory *et al.* 2007, Reif *et al.* 2007, European Bird Census Council 2016), or splitting all common and widespread breeding bird species (Gregory *et al.* 2003), or even all regularly breeding species (Zbinden *et al.* 2005), into habitat categories. Another alternative is the analysis of the habitat preferences of birds using the count data of existing CBMS (e. g. Ostasiewicz *et al.* 2011, Szép *et al.* 2012, Eskildsen *et al.* 2013), which has the advantage of an objective selection procedure. Anyway, in this approach – as well as in some of those mentioned above – it is only possible to include species which are counted regularly in a CBMS. Thus, potential indicator species which are not monitored are left out, which can lead to an indicator that does not cover all ecological needs of bird species living in the habitat of interest. Therefore we adopted the approach developed by Butler *et al.* (2012) and Wade *et al.* (2014), where (1) all species using a habitat are included in the selection procedure, and (2) the overlap between resource uses is minimised. This is the first-time application of this concept to the forest bird community at a single-country level.

2. Methods

2.1 Forest definition

For the purpose of our study we adopted the definition of 'forest' as used in the Austrian Forest Inventory (Österreichische Waldinventur), which includes all stands of an area ≥ 500 m^2, with a cover of > 30 % and a width ≥ 10 m (details see Hauk & Schadauer o. J., Fig. 1). Additionally, we included the zones of krummholz as well as of Dwarf Mountainpine *Pinus mugo* – both of which occur at high altitudes adjacent to forests, and often are highly interlocked with the latter.

2.2 Indicator species selection

2.2.1 Species list

We used a list of 67 bird forest species as starting point for the selection procedure. The species list was based on a European list of 80 candidate indicator species compiled by Wade *et al.* (2014). From that list we selected species (1) which breed in Austria, (2) with a population size ≥ 200 breeding pairs, and (3) excluded all species being indicator species in the Austrian FBI (see Teufelbauer & Frühauf 2010). Finally, we changed the status of three species based on expert judge-

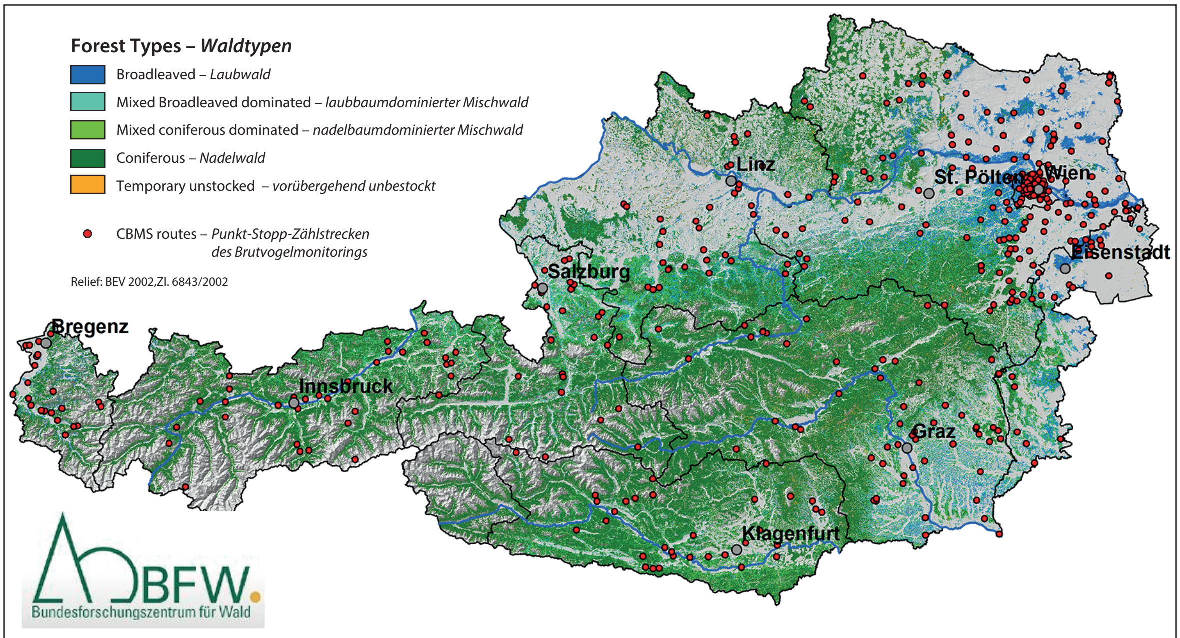

Fig. 1: Distribution of point count routes of the Austrian common bird monitoring scheme and different forest types in Austria. – *Verteilung der Punkt-Stopp-Zählstrecken des Monitoring der Brutvögel Österreichs.*

ment: on the one hand we removed Buzzard *Buteo buteo* and Greenfinch *Chloris chloris* from the list of forest species, as both show a strong linkage to other habitats (farmland and settlements, respectively), and on the other hand we added Lesser Whitethroat *Sylvia curruca* to the list because a substantial part of the Austrian population inhabits the zones of krummholz and Dwarf Mountainpine (Dvorak *et al.* 1993, BirdLife Austria unpublished data), which we included in our definition of forests (see above).

2.2.2 Resource use and sensitivity

The selection procedure was based on the work of Butler *et al.* (2012) and Wade *et al.* (2014), who used an objective, niche-based approach to (1) cover all resources in forests that are used by the forest bird species community, and (2) minimise the overlap of resource use between single indicator species. We categorised the resource use of each species in a resource requirements matrix. We used a simple binary code (0/1) for the categories summer diet, winter diet, summer foraging habitat, winter foraging habitat, nest type and nesting habitat. To include information of forest age we extended the original matrix of Wade *et al.* (2014) with information on successional stage. All categories used are shown in Table 1. For the categorisation we used the extensive overview on species' biology 'Handbuch der Vögel Mitteleuropas' (Glutz von Blotzheim *et al.* 1966-1997) as well as personal expertise on the situation in Austria.

In the groups diet and foraging habitat (each summer and winter) as well as nest type and nesting habitat all combinations which were theoretically possible and biologically useful were identified. The overall number of these resource combinations equals the range of ecological niches used by birds in forests in Austria. After the selection process each of these resource combinations should be represented by at least one species in the final indicator.

Each species of the initial list was classified according to its reliance on forests: species exclusively dependent on forests were classified with 1, species with intermediate dependence on forests with 2, and species with low dependence on forests were classified with 3, respectively. The classification was done independently by eight Austrian expert ornithologists, whose results were combined using modal value. A sensitivity score was calculated for each species after $S = N * R$, where N = number of used resources, R = reliance on forests, and S = sensitivity.

2.2.3 Selection procedure

Finally, a species selection algorithm using the concept of minimum dominating sets was applied to identify optimal species combinations for each possible number of indicator species (Wade *et al.* 2014). For each possible number of indicator species we selected the combination with the lowest average sensitivity score. By using a piecewise regression on these combinations we identified the optimal number of indicator species (Wade *et al.* 2014). We ran this selection procedure twice: firstly for all 67 forest species in our initial species list, resulting in the optimal indicator WBI_{opt}, and secondly only including those species for which data on population trends is available.

2.3 Trend data

2.3.1 Common Bird Monitoring

Data on common Austrian breeding birds was obtained from the common bird monitoring scheme 'Monitoring der Brutvögel Österreichs' (henceforth abbreviated with ACBMS). This scheme is run by BirdLife Austria and relies predominantly on volunteer observers ('citizen science'; see Greenwood 2007). Counts are done twice in the breeding season, with the first count conducted in the second half of April and the beginning of May, and the second count conducted in the second half of May and the beginning of June. At high altitudes (approx. above 1,200 m. a. s. l.) the two counts are done later in the season, individually adjusted to the local conditions (snow cover, danger of avalanches). The ACBMS uses point counts. The count points are grouped into routes which comprise 12.1 ± 3.3 points (mean ± std. dev.). On average, 236 ± 13 routes are counted every year (mean 2008–2012). The distribution of routes and the distribution of forest types in Austria are depicted in Fig. 1. More details on the ACBMS can be found e. g. in Teufelbauer (2010), Teufelbauer & Frühauf (2010) and Teufelbauer & Seaman (2016).

2.3.2 Species trends and indicators

Population trends were calculated using the standard procedure suggested by van Strien & Soldaat (2008), using TRIM software (Pannekoek & van Strien 2001). Where possible, the trend for each indicator species was stratified and weighted according to population size in the nine Austrian federal states (post-hoc stratification; Gregory & Greenwood 2008; van Turnhout *et al.* 2008). For details see Teufelbauer (2010). In this paper we used ACBMS data from the starting year 1998 up to the year 2012. The multi-species indicators resulting from the selection procedure (WBI_a, WBI_b), as well as an indicator including all candidate indicator species with available trend data (WBI_{all}), were calculated using geometric mean (Gregory *et al.* 2005). The Austrian FBI, which we used for comparison, was redrawn from Teufelbauer (2013a).

We applied Monte-Carlo-Simulations to calculate trends and standard errors for the resulting multi-species indicators (MSI-tool for R, Soldaat 2016, Soldaat *et al.* submitted): This approach is based on the approximately log-normal distribution of the standard errors of index values. For each yearly index value and for each species we drew 10,000 times from a normal distribution $N(\mu, \sigma)$, with μ = the natural logarithm of the index and σ = the standard error of the index on the log scale. The standard error of the index on the log scale was assessed by the Delta-method (e. g. Agresti 1990). We calculated mean and standard error for the resulting 10,000 multi-species indicators. Information on trend of the multi-species indicators used in this paper comprises the overall trend and the standard error of the overall trend. The classification of trends follows the procedure used in the TRIM software for analysis of time series in biological data (Pannekoek & van Strien 2001). Finally, to test for differences in trends between the multi-species indicators, we calculated mean trends, standard errors and confidence limits of the trends from 10,000 draws from the normal distribution of the index values of the multi-species indicators, again using Monte-Carlo-Simulation (Soldaat 2016, Soldaat *et al.* submitted).

2.3.3 Representativeness

In a country with a large proportion of mountains like Austria it is hard to achieve a representative distribution of ACBMS routes. Uneven sampling of, for example high altitude forests, can be corrected to some extent by the use of post-hoc stratification (see above), but major imbalances might not be

Table 1: Categories used in the resource requirements matrix. – *In der Ressourcen-Anforderungs-Matrix verwendete Kategorien.*

Level 1 – *Ebene 1*	Level 2 – *Ebene 2*	Level 3 – *Ebene 3*
Summer diet – *Sommernahrung*	Below-ground invertebrates – *bodenlebende Evertebraten*	
	Above-ground invertebrates – *außerhalb des Bodens lebende Evertebraten*	
	Plant material – *Pflanzenmaterial*	
	Seeds – *Samen*	
	Vertebrates – *Wirbeltiere*	
Winter diet – *Winternahrung*	Below-ground invertebrates – *bodenlebende Evertebraten*	
	Above-ground invertebrates – *außerhalb des Bodens lebende Evertebraten*	
	Plant material - *Pflanzenmaterial*	
	Seeds – *Samen*	
	Vertebrates – *Wirbeltiere*	
Summer foraging habitat – *Nahrungshabitat Sommer*	Forest type – *Waldtyp*	Deciduous – *Laubwald*
		Coniferous – *Nadelwald*
		Mixed – *Mischwald*
	Successional stage – *Sukzessionsstadium*	Young/intermediate – *jung/mittel*
		Old – alt
		Need of dead wood – *Bedarf an Totholz*
	Horizontal habitat – *Habitat horizontal*	Edge – *Rand*
		Core – *Bestandesinneres*
	Vertical habitat – *Habitat vertikal*	Ground – *Boden*
		Shrub – *Strauch*
		Canopy – *Kronenbereich*
Winter foraging habitat – *Nahrungshabitat Winter*	Forest type – *Waldtyp*	Deciduous – *Laubwald*
		Coniferous – *Nadelwald*
		Mixed – *Mischwald*
	Successional stage – *Sukzessionsstadium*	Young/intermediate – *jung/mittel*
		Old – alt
		Need of dead wood – *Bedarf an Totholz*
	Horizontal habitat – *Habitat horizontal*	Edge – *Rand*
		Core – *Bestandesinneres*
	Vertical habitat – *Habitat vertikal*	Ground – *Boden*
		Shrub – *Strauch*
		Canopy – *Kronenbereich*
Nest type – *Nesttyp*		Hole - dead wood – *Höhle in Totholz*
		Hole - live wood – *Höhle in lebendigem Holz*
		External – *frei nistend*
Nest habitat – *Nisthabiat*	Forest type – *Waldtyp*	Deciduous – *Laubwald*
		Coniferous – *Nadelwald*
		Mixed – *Mischwald*
	Successional stage – *Sukzessionsstadium*	Young/intermediate – *jung/mittel*
		Old – alt
		Need of dead wood – *Bedarf an Totholz*
	Horizontal habitat – *Habitat horizontal*	Edge – *Rand*
		Core – *Bestandesinneres*
	Vertical habitat – *Habitat vertikal*	Ground – *Boden*
		Shrub – *Strauch*
		Canopy – *Kronenbereich*

overcome by the applied stratification approach. Therefore we checked the representativeness of the ACBMS counts using two simple parameters: altitude (≤600 m, 601–1,200 m and >1,200 m) and forest type (deciduous, coniferous, and mixed; data on both parameters from Bundesforschungszentrum für Wald unpublished). The locations of the ACBMS count points were assigned to these parameters using a geographical information system. We then calculated the number of count points for each class of the two parameters.

To assess the representation of different migration strategies in the selected indicator species we classified all candidate indicator species according to their migration strategy based on information in Glutz von Blotzheim *et al.* (1966–1997) and on personal expertise. For the three categories resident/partially migratory, short-distance migrant, and long-distance migrant we checked with Pearson's Chi Square test whether the distribution of migration strategies in the basket of the selected indicator species deviated from the initial pool of candidate indicator species.

3. Results

Together, the 67 candidate indicator species used 631 resource combinations of the resource requirements matrix. The set of 47 species for which data on population trends is available used 547 resource combinations (87 % of the total number of resource combinations). The ideal indicator, covering all 631 resource combinations, was composed of 26 species (WBI_{opt}). The indicator based only on species with available trend data comprised 19 species (Table 2). For the latter, two different species combinations with the same average sensitivity were obtained – one set contains Coal Tit *Parus ater* [Woodland Bird Index (a), or WBI_a], whereas in the other set this species was substituted by Willow Warbler *Phylloscopus trochilus* (WBI_b). The two indicators comprising 19 species are shown in Fig. 2. The two versions of the WBI did not differ significantly from one another (overall trend $WBI_a = -1.13 \pm 0.20$ %/year, $WBI_b = -1.26 \pm 0.19$ %/year). The trends of both indicators were significantly different from zero and showed a moderate decrease ($p < 0.05$). The trend of a multi-species indicator including all forest species with available trend data (WBI_{all}) did not differ significantly from the trends of WBI_a and WBI_b ($WBI_{all} = -1.30 \pm 0.15$ %/year; Fig. 2).

The checks of representativeness showed that the sample effort is unevenly distributed within the two tested parameters, with effort being lowest at high altitudes and also in mixed and coniferous forests (Fig. 3). The selection procedure did not favour any of the migration strategies of the candidate indicator species set: Whereas the figures indicate a slight preference of migratory over residential bird species in both, the optimal indicator WBI_{opt} as well as the two indica-

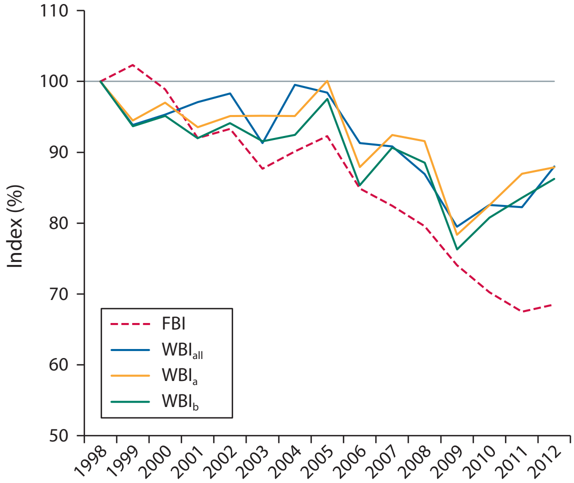

Fig. 2: Woodland Bird Index comprising the 19 indicator species identified in the selection procedure (WBI_a, WBI_b) and the multi-species indicator comprising all forest species with available trend data (WBI_{all}). For comparison the trend of the Austrian Farmland Bird Index is also drawn (FBI). Note that for the sake of increased perceptibility the Y-Axis does not include zero. – *Woodland Bird Index bestehend aus den Bestandstrends jener 19 Vogelarten, die im Auswahlprozess selektiert wurden (WBI_a, WBI_b) sowie ein Summenindikator, der sich aus allen Waldvogelarten mit verfügbaren Bestandstrends zusammensetzt (WBI_{all}). Zum Vergleich ist auch der österreichische Farmland Bird Index dargestellt (FBI). Zur besseren Unterscheidung der Trends ist die Y-Achse nicht bis zum Nullpunkt gezeichnet.*

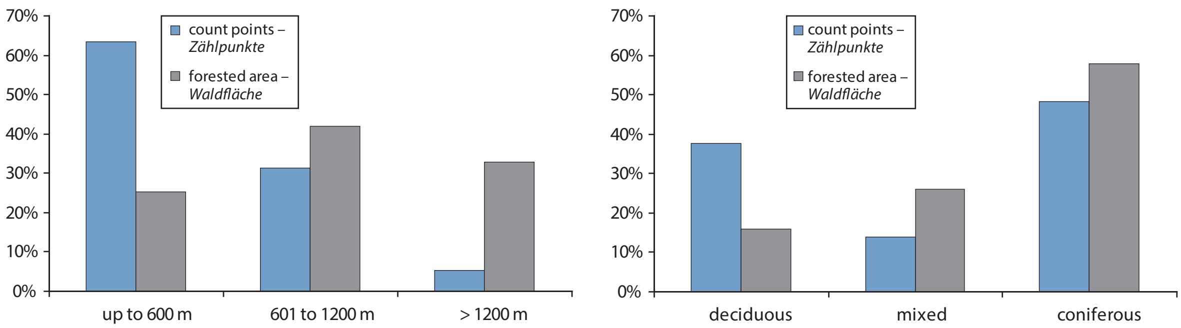

Fig. 3: Sampling effort of the Austrian common bird monitoring scheme in relation to altitude (left) and altitude (right). Total forest area: 3.99 million hectares, total number of count points: 1,032. – *Zählaufwand des österreichischen Brutvogel-Monitoring in Bezug auf Seehöhenklassen (links) und Waldtypen (rechts). Waldfläche gesamt: 3,99 Mio. Hektar, Anzahl Zählpunkte gesamt: 1.032.*

Table 2: Selected indicator species: (1) Ideal indicator, i. e. selection based on all candidate species, (2) indicator that is feasible at the moment, i.e. selection based only on candidate species with available trend data. [1] the selection procedure resulted in two species sets with identical sensitivity which differ in the marked species. – *Ausgewählte Indikatorarten: (1) Idealer Indikator: Artenauswahl basierend auf allen Arten der Vorauswahl, (2) im Moment realisierbarer Indikator: Artenauswahl basierend nur auf jenen Arten der Vorauswahl, für die derzeit Daten zur Bestandsentwicklung vorliegen. [1] Der Auswahlprozess lieferte zwei Artensets mit identischer Sensibilität, die sich nur in den beiden gekennzeichneten Arten unterscheiden.*

English name – *Englischer Name*	Scientific name – *Wissenschaftlicher Name*	all species – *alle Arten*	species with trend data – *Arten mit Daten zur Bestandsentwicklung*
Black Stork	*Ciconia nigra*	x	
Woodcock	*Scolopax rusticola*	x	
Stock Dove	*Columba oenas*	x	x
Cuckoo	*Cuculus canorus*	x	x
Pygmy Owl	*Glaucidium passerinum*	x	
Tawny Owl	*Strix aluco*	x	
Black Woodpecker	*Dryocopus martius*	x	x
Great Spotted Woodpecker	*Dendrocopos major*	x	x
Middle Spotted Woodpecker	*Dendrocopos medius*	x	
Lesser Spotted Woodpecker	*Dryobates minor*	x	
Three-toed Woodpecker	*Picoides tridactylus*	x	
Wren	*Troglodytes troglodytes*	x	x
Robin	*Erithacus rubecula*	x	x
Nightingale	*Luscinina megarhynchos*	x	x
Blackbird	*Turdus merula*	x	x
Western Bonelli's Warbler	*Phylloscopus bonelli*	x	x
Wood Warbler	*Phylloscopus sibilatrix*	x	x
Willow Warbler	*Phylloscopus trochilus*		(x)[1]
Goldcrest	*Regulus regulus*	x	x
Firecrest	*Regulus ignicapilla*	x	x
Red-breasted Flycatcher	*Ficedula parva*	x	
Collared Flycatcher	*Ficedula albicollis*	x	x
Marsh Tit	*Parus palustris*	x	x
Crested Tit	*Parus cristatus*	x	x
Coal Tit	*Parus ater*		(x)[1]
Golden Oriole	*Oriolus oriolus*	x	x
Jay	*Garrulus glandarius*	x	x
Crossbill	*Loxia curvirostra*	x	x

tor versions WBI_a and WBI_b obtained from the group of species where trend data is available (Fig. 4), these differences were statistically not significant in all cases (all species vs. WBI_{opt}: $\chi^2 = 0.15741$, df = 2, p = 0.9243; WBI_{all} vs WBI_a: $\chi^2 = 0.61238$, df = 2, p = 0.7362; WBI_{all} vs WBI_b: $\chi^2 = 1.108$, df = 2, p = 0.5747).

4. Discussion

4.1 Selected indicator species and covered time span

In this study we have selected indicator species for the Austrian Woodland Bird Index based on an objective approach. We identified the optimal indicator species, but, given that yearly trend data was not available for some of these, we decided to build a preliminary indicator. This indicator is based on species for which trend data is already available and therefore it is ready-to-use. Moreover, it covers the time span from 1998 onwards – the starting year of the ACBMS – which is of great importance, because long time-series help to detect changes in a timely manner (see Gregory *et al.* 2008). This currently feasible indicator covers a large proportion of all forest resources used by birds (87 %) and we therefore believe it is able to deliver valuable information on the status of the birds in this habitat, even if some species are not included. In the long-term the aim should be to collect data for all species of the optimal indicator. As some of these birds are difficult to monitor (see below) this will be a major task for both, NGO work and governmental nature conservation bodies. Nevertheless, without these species some resources remain unrepresented in the WBI, which could lead to the situation that changes relevant for birds in Austrian forests might remain undetected. This would hamper one of the major tasks of the WBI, namely acting as an early warning system (Gregory *et al.* 2008).

4.2 Representativeness

4.2.1 Indicator species with no available trend data

All of the ideal indicator species for which no trend data is available are hard to monitor with the standard

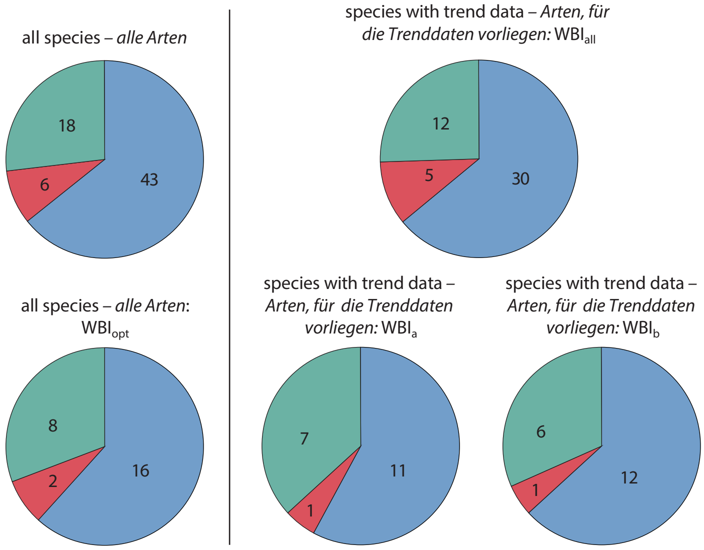

Fig. 4: Ratios of migration strategies in different indicator species sets. Left: All 67 candidate species used in this study (top), and the set of 26 indicator species that were selected for the optimal WBI$_{opt}$ (bottom). Right: The 47 candidate indicator species for which trend data is available (top) and the 19 species selected for the two indicator versions (WBI$_a$, WBI$_b$). Blue: resident and partly migratory species, red: short distance migrants, green: long-distance migrants. – *Anteile der Zugstrategien in verschiedenen Sets von Indikatorarten. Links: Alle 67 Arten der Vorauswahl (oben), sowie jene 26 Indikatorarten, die zusammen den idealen Indikator bilden (unten). Rechts: Die 47 Vogelarten der Vorauswahl, für die Trenddaten vorliegen (oben), sowie jene 19 Arten, die für die beiden Versionen des Indikators ausgewählt wurden (WBI$_a$, WBI$_b$). Blau: Standvögel und Teilzieher, rot: Kurzstreckenzieher, grün: Langstreckenzieher.*

method of the ACBMS: (1) Some are crepuscular or nocturnal (Pygmy Owl *Glaucidium passerinum*, Tawny Owl *Strix aluco*, Woodcock *Scolopax rusticola*, Glutz von Blotzheim *et al.* 1966–1997) and are thus regularly missed by the counts that are conducted in the morning (Teufelbauer 2010). (2) Most of them have rather large territories and generally occur in low densities (all except Middle Spotted Woodpecker *Dendrocopos medius*, Glutz von Blotzheim *et al.* 1966–1997) and are therefore registered only rarely during the point counts of the ACBMS. (3) Some are habitat specialists and therefore have restricted breeding ranges (Middle Spotted Woodpecker, Red-breasted Flycatcher *Ficedula parva*, see Dvorak *et al.* 1993) which makes it even harder to reach sample sizes that enable a trend calculation. Feeding on vertebrates is a characteristic trait shown by three of these seven species (Black Stork *Ciconia nigra*, Pygmy Owl, Tawny Owl; Glutz von Blotzheim *et al.* 1966–1997). This resource use is not covered by any of the species of WBI$_a$ or WBI$_b$. Furthermore, these seven species show a more or less pronounced restriction to old growth forests, some additionally bound to the occurrence of substantial amounts of dead wood. It is crucial to keep this in mind when interpreting the trend of the current indicator, as changes in these resources – subsequently influencing bird populations – might remain undetected by the WBI.

4.2.2 Distribution of the point counts

A further potential pitfall in the interpretation of the trend of the WBI is the current distribution of ACBMS count routes in Austria. Mixed forests and coniferous forests are undersampled, as well as forests at higher altitudes (Fig. 3). Although a stratification and weighting procedure is applied in the analysis of the count data (see methods), it should be noted that, due to this uneven distribution, the resulting WBI might be biased to lowland deciduous forests. We therefore recommend – beside the aforementioned collection of trend data for some species currently not monitored on a yearly basis – an extension of the ACBMS counts in higher altitudes, where the proportion of coniferous forests per se is higher than in lowland forests (Kilian *et al.* 1994).

4.2.3 Indicator species with different migration strategies

The applied selection procedure slightly prefers migratory over resident and partly-migratory species, although this preference is statistically not significant. This effect is caused by the number of resources used per species: In the resource requirements matrix the resource use in summer is dealt with separately from resource use in winter. The total number of used resources is therefore on average higher in species which are present all year round ($N_{res} = 60 \pm 55$, $N_{mig} = 22 \pm 22$, mean ± std. dev, n = 67 candidate indicator species) This leads to better, i.e. lower, sensitivity scores for migratory species ($S_{res} = 77 \pm 80$, $S_{mig} = 38 \pm 64$) and, because the algorithm per definition selects the most specialised species, migratory species are preferred over residential ones (see method). A preference for long-distance migrants can be problematic, because it has been reported repeatedly that bird species migrating long-distances, i.e. to Africa south of the Sahara, experience more negative declines than short-distance migratory or resident bird species (e.g. Sanderson *et al.* 2006, Vickery *et al.* 2014). Nevertheless, this finding does not seem to be valid for Austria (Teufelbauer/BirdLife Austria, unpublished data), and furthermore the proportions of migratory strategies in the baskets of indicator species do not differ significantly from the baskets of the candidate indicator species. Thus we think that the overall influence of this characteristic of the selection algorithm on the WBI is negligible.

4.3 Trend of the WBI

We found no significant difference between the trends of the WBI based on the species selection (WBI_a, WBI_b) and the indicator incorporating all species for which trend data is available (WBI_{all}). Thus, at first glance the performed selection procedure might appear unnecessary. However, it should be noted that this estimation is only true for (1) the current length of the time series – theoretically this can change with the addition of every single year of data – and (2) the current set of species with available trend data. Contrary to the first-sight impression, we believe that conducting the selection procedure is crucial for the aims of the WBI, because we were able to identify resources which are currently not covered by the indicator. This is a finding that would have been impossible if we had simply combined the available population trends of forest bird species. Furthermore, the approach minimises redundancies in the resource use, which is a very valuable asset for potential future developments in forests.

The trends of the WBI (WBI_a, WBI_b) are significantly less negative than the trend of the Austrian FBI, although the trend of the FBI still qualifies as a 'moderate decrease' only (FBI = -2.96 ± 0.21 %/year; Fig. 2). The more negative development of farmland birds is in line with the results of both other European countries (e. g. Reif *et al.* 2007, Ostasiewicz *et al.* 2011) as well as the European level as a whole (Gregory *et al.* 2007). The majority of the WBI's indicator species exhibits statistically significant negative population trends (Teufelbauer/BirdLife Austria unpublished data), which all in all drive the trend of the WBI. Negative trends occur in particular in all species living predominantly or exclusively in coniferous forests (Goldcrest *Regulus regulus*, Firecrest *Regulus ignicapilla*, Crested Tit Parus cristatus, Coal Tit, Common Crossbill *Loxia curvirostra*; Teufelbauer 2013b). This is in line with an ongoing decline of the area forested with coniferous trees since the 1980s, which on the other side has been more than balanced by a gain of deciduous trees (Russ 2011). Nevertheless, it is possible that the WBI is drawing too negative a picture, at least in part: The decline of both coniferous forests as well as of spruce, the major species of coniferous forests in Austria, is largest in forests below 900 m. a. s. l. (BFW 2016). Together with the current distribution of count routes of the ACBMS, which leads to an oversampling of lowland forests and an undersampling of high altitude forests (see Fig. 3), it is likely that this effect is exaggerated in the trend of the WBI, but is somewhat weaker in reality. More work is needed to secure this hypothesis, as well as to gain a general understanding of the population trends of Austrian forest birds. In any case, we recommend intensifying the efforts of common bird monitoring in Austria to be able to document the trends of Austria's forest birds with higher certainty. Emphasis should be put on (1) increasing the sampling effort in higher altitude mixed and coniferous forests, and (2) collecting data for those indicator species of the optimal forest bird indicator (WBI_{opt}) which are currently not monitored on a yearly basis.

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5. Zusammenfassung

Teufelbauer, N., R. Büchsenmeister, A. Berger, B. S. Seaman, B. Regner, E. Nemeth & S. J. Butler 2017: Entwicklung eines Waldvogelindikators für Österreich. Vogelwelt 137: 215–224.

Summenindikatoren kombinieren die Bestandsentwicklungen von Vogelarten, beispielsweise in einem ausgewählten Lebensraum. Sie sind ein wertvolles Werkzeug für den Naturschutz, denn über eine kluge Auswahl der Indikatorarten liefern sie eine Zusammenfassung der Veränderungen, die in der gesamten Vogelartengemeinschaft dieses Lebensraumes passieren. In dieser Arbeit berichten wir von der Entwicklung eines Waldvogelindikators für Österreich, der stellvertretend über eine Gruppe von Indikatorarten die Populationsentwicklung aller Waldvogelarten darstellen soll. Zur Auswahl der Indikatorarten verwendeten wir einen objektiven Ansatz, der auf den jeweils von den Arten genutzten ökologischen Nischen basiert. Dieser Ansatz wurde von Wade *et al.* (2014) für Waldvogelarten auf europäischer Ebene entwickelt und unsere Arbeit ist die erste Anwendung auf Waldvogelarten auf Ebene eines Einzelstaates. Die Auswahl der Indikatorarten erfolgte nach zwei Regeln: (1) Alle Ressourcen, die von Waldvogelarten genutzt werden, sollten von den Indikatorarten abgedeckt werden. Dazu wurde die Ressourcennutzung der untersuchten Vogelarten für die Kategorien Sommernahrung, Winternahrung, Nahrungshabitat im Sommer, Nahrungshabitat im Winter, Nesttyp und Nisthabitat mit jeweils mehreren möglichen Klassen definiert. (2) Die ausgewählten Arten sollten so spezialisiert wie möglich sein. Dazu benutzten wir die errechnete Sensitivität der untersuchten Vogelarten, ausgehend einerseits von ihrer Abhängigkeit vom Lebensraum Wald und andererseits von der Zahl der jeweils von ihnen genutzten Ressourcen.

Der Auswahlprozess basierte auf einer Liste aller österreichischen Waldvogelarten mit einem Bestand von mindestens

200 Brutpaaren. Der Auswahlprozess lieferte 26 Vogelarten, die zusammen das optimale Set an Indikatorarten bildeten. Allerdings waren jährliche Daten zur Bestandsveränderung für acht dieser Arten nicht verfügbar: Schwarzstorch, Waldschnepfe, Sperlingskauz, Waldkauz, Mittelspecht, Kleinspecht, Dreizehenspecht und Zwergschnäpper. Aus diesem Grund führten wir den Auswahlprozess ein zweites Mal durch, diesmal eingeschränkt auf jene Arten, für die jährliche Daten zur Bestandsveränderung vorliegen. Die Datenquelle dafür war das Zählprogramm „Monitoring der Brutvögel Österreichs" von BirdLife Österreich, das seit 1998 jährlich durchgeführt wird. Dieser Auswahlprozess lieferte zwei Sets an Indikatorarten, die nach den Kriterien der Auswahl beide gleich gut geeignet waren. Die Sets bestanden beide aus 19 Indikatorarten, und sie unterschieden sich lediglich in einer einzigen Art: Hohltaube, Kuckuck, Schwarzspecht, Buntspecht, Zaunkönig, Rotkehlchen, Nachtigall, Amsel, Berglaubsänger, Waldlaubsänger, Wintergoldhähnchen, Sommergoldhähnchen, Halsbandschnäpper, Sumpfmeise, Haubenmeise, Pirol, Eichelhäher, Fichtenkreuzschnabel und entweder Fitis oder Tannenmeise.

Die Trends der aus diesen beiden Sets gebildeten Waldvogelindikatoren unterschieden sich nicht signifikant voneinander. Ebensowenig unterschieden sich diese beiden Trends von der Bestandsentwicklung aller Vogelarten der Auswahlliste, für die Daten zur Bestandsentwicklung vorlagen. Alle drei Trends rangierten in einem Bereich von -1,13 %/Jahr bis -1,30 %/Jahr. Trotz dieses Ergebnisses halten wir es für wichtig, zur Erstellung des Waldvogelindikators für Österreich einen objektiven und formellen Auswahlprozess durchzuführen. Insbesondere das Ergebnis des optimalen Indikators zeigt klar auf, welche ökologischen Nischen derzeit in dem Indikator nicht abgebildet werden können. Das betrifft insbesondere Vogelarten, die Wirbeltiere als Nahrungsgrundlage nutzen, sowie Arten, die als Lebensraum alte und totholzreiche Wälder benötigen. Des Weiteren zeigte sich, dass die Datenerfassung aus dem Monitoring der Brutvögel Österreichs besonders Misch- und Nadelwälder in höheren Lagen untererfasst. Daher empfehlen wir die Ausweitung des Vogelmonitorings, um in einem zukünftigen Waldvogelindikator die gesamte Vogelartengemeinschaft von Österreichs Wäldern gut abbilden zu können.

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