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THE IMPORTANCE OF POTENTIAL IMPACT OF CLIMATE CHANGE ON BIRD SPECIES COMPOSITION IN DESIGNING EFFECTIVE WAYS OF BIRD PROTECTION AND MANAGEMENT: A CASE STUDY FROM THE EASTERN BALTIC REGION

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Abstract. Of the 207 breeding species considered in Lithuania, results of the review show that with a north-easterly shift in their range, the 33 (16%) species breeding on the western, south-western and southern peripheries of their total species range may be significantly affected and are likely to become extinct in the region. Species in different habitat types may suffer differently, the most vulnerable bird species being those breeding in wet habitats. By contrast, communities in dry habitats hold the least number of potentially vulnerable breeding species. The remaining 174 species (84%), those with their breeding populations in the northern, north-eastern, eastern and north-western peripheries of their ranges and in the central part of species range, may benefit from climate warming and are unlikely to become extinct. The patchiness of the breeding range, the species breeding in wet habitats and the position of the southern, south-western and western peripheries of the entire species range are shown to be directly interconnected and, with further climate warming throughout the 21st century, these Lithuanian breeding species are likely to face the greatest risk of extinction. Additionally, climate change may not be the only threat to the species due to other factors, such as changes in land use. Bird diversity variation under the impact of climate change is a serious problem facing the world and we must find new effective measures of bird protection.

Keywords: shift of ranges, risk of species extinction, climate change, environmental politics.

1. Introduction

It is obvious that global climate change is affecting the Earth's ecosystems (Brommer 2004; Viksne *et al.* 2005; Huntley *et al.* 2007; Žalakevičius 2007). As a rule in the Northern Hemisphere the northern range boundaries of breeding birds are limited by cold temperatures; while the southern range limit is determined by heat or lack of water (Newton 2008). Therefore, the majority of birds breeding at the northern, north-eastern and eastern peripheries of the range may benefit from climate warming, whereas the birds breeding at southern, south-western and western periphery may suffer (a decline in numbers of the latter species is observed due to decrease of precipitation amount and soil humidity). Range boundaries also may be restricted by geographical or landscape features, such as mountain ranges or oceans.

Climate models designed for the eastern Baltic region for the 21st century predict increase in air temperatures. The greatest absolute change anticipated for the cold season. Precipitation amount will grow in winter and spring and drop in summer and autumn. Thus the second half of summer and the beginning of autumn in Lithuania will be marked by greatly enhanced aridity (Rimkus *et al.* 2007). With decreased precipitation and increased surface evaporation resulting from the rising temperatures in the future, Lithuanian wetlands and wet habitats are likely to be markedly affected by climate change (Stonevičius *et al*. 2008; Žalakevičius *et al*. 2009).

Moreover, climate change has impact upon phenology of birds (Romanovskaja *et al.* 2009; Veriankaitė *et al.* 2010). In breeding places long-distance migrants may not be able to evaluate changes in food objects phenology evoked by climate warming. Potentially, this leads to mismatch between hatching dates and food peak-abundance dates (Dunn 2004; Both *et al.* 2006). It is obvious that alterations in all the said climate parameters will have a direct or indirect impact on bird populations breeding in Lithuania, their total numbers, the species composition, the areas occupied and species survival.

Some research results point to shifts in the breeding ranges of bird species resulting from the impact of climate warming in the Northern Hemisphere (Brommer 2004; Zuckerberg *et al.* 2009). In Great Britain and North America, the ranges shift in a northern direction (Zuckerberg *et al.* 2009), whereas in the Baltic countries, due to geographic position of the eastern Baltic region and possibly to climate features, the shift is in a north-eastern direction (Žalakevičius 2007).

The largest and most recent study to forecast ranges of European birds for the 21st century (Huntley *et al.* 2007) was performed on the results of *The EBCC Atlas of European Breeding Birds* (Hagemeijer, Blair 1997) and small number of climatic variables using up-to-date

modelling methods. The aim of this research was to review possible changes in breeding bird species composition due to climate change throughout the 21st century. Specific objectives of the research are to identify possible changes in species composition: a) in different parts of species range; b) in different level of wetness of various habitats; c) in diversified continuity of breeding ranges.

In this article, assessments are made for the survival of the breeding populations of 207 bird species in Lithuania, presuming shifts in the ranges of the breeding species under the impact of climate warming. This publication is a survey of the present situation in Lithuania and the eastern Baltic region and a discussion of future prospects in the light of recent and future expected climate change and its possible impacts.

2. Material and methods

All 207 bird species breeding in Lithuania were considered in the survey. Potential future breeding distribution forecasts for each species were performed using our results and statements in publications of different authors indicating a predominantly north-easterly shift of ranges in the region, including Lithuania, Latvia and Belarus due to geographical position of the region of Baltic Sea (Žalakevičius 1999). Thus, it is likely that with climate warming, bird species with populations at the southern, south-western and western peripheries of their entire species ranges suffer, whereas those at the northern, north-eastern and eastern peripheries of their range benefit. It seems likely that species in the central part and north-western periphery of their ranges may not face the great impact and in our article are attributed to those that may benefit from the situation.

Basing on the above logical scheme and newly updated information on ranges (Snow, Perrins 1998; Huntley *et al.* 2007), the 207 species presently breeding in Lithuania were classified and estimated based on the position that their populations occupy relating to the position of their entire range of species distribution. The results were compared with the forecast for species breeding in Lithuania for the 21st century published by Huntley *et al.* (2007) because so far Huntley's forecast for our region was the only available and the most comprehensive.

While analysing the reviewed data, consideration has been also taken of range character – continuity of population range, i.e. whether the Lithuanian breeding populations of the investigated species are in the continuous species range or in a restricted range or its patches (outside the boundaries of the continuous range). Furthermore, attempts have been made to determine the impact of birds' migration distance on potential extinction of birds in the face of climate change. Therefore, all the analysed bird species have been divided into three groups: long-distance migrants; short/medium-distance migrants; and resident, sedentary or vagrant.

Data from the EBCC Atlas of European Breeding Birds (Hagemeijer, Blair 1997) were used to classify breeding bird species according to geographical position of theirs Lithuanian populations with respect to periphery of species range. Information on historical shifts of ranges of breeding bird species was taken from the presentable array of old and new publications (Taczanowski 1882a, 1882b; Tischler 1941; Ivanauskas 1957, 1959a, 1959b, 1964; Valius *et al.* 1977; Logminas 1990, 1991; ***Nikiforov*** *et al.* 1997**;** Švažas 2001, BirdLife International 2004; Kurlavičius 2006).

The article also focuses on bird habitat selection for nesting and feeding during the breeding and brood raising period in Lithuania. According to habitats used, bird species have been roughly broken down into five groups, i.e. species related to: 1) freshwater habitats; 2) wet open and semi-open areas; 3) dry open and semi-open territories; 4) wet woodland and 5) dry woodland habitats. The grouping allowed the assessment of the importance of the utilized habitats for the species possible survival in the 21st century under the enhanced impact of climate change. In the classification of habitats, we emphasized the role of the hydrological regime for species-specific environment. We assumed that wetness of habitats decreases with temperature rise and due to general lack of water with precipitation decrease.

Values of monthly air temperatures (°C) for 1950–2009 were obtained from the Archive of the Lithuanian Hydrometeorological Service. To establish the reliability of difference in species numbers of different categories of survival in various habitats with diversified continuity of population range, the Log linear analysis of frequency tables was used (the STATISTICA 6 package for Microsoft Windows 2000).

3. Results and discussion

Research of climate in the region indicates warming trend in winter (Spearman rank correlation: $r = 0.34$, $N = 60$, $p<0.01$), in spring ($r = 0.51$, $N = 60$, $p<0.01$) and summer ($r = 0.32$, $N = 60$, $p<0.05$) in Lithuania since 1950. Temperature in autumn has no distinct changes (Fig. 1). Since the 1970s, positive spring temperature deviations have become dominant and since 1988 positive winter and summer temperature deviations have prevailed.

Since 1950, precipitation amount in warm (APR-OCT) period decreases, whereas in cold (NOV-MAR) period increases (Žalakevičius *et al.* 2006). In warm period precipitation amount is more expressed in spring and autumn (Fig. 2).

Analysis of the 207 investigated breeding species shows that 92 of them (44.4%) are long-distance migrants, 69 (33.3%) short- or medium-distance migrants and 46 (22.3%) resident, sedentary or vagrant. As global warming progresses, 174 species (84.0%) are likely to benefit from the situation, namely those with their populations in the region at the northern, north-eastern, eastern and north-western peripheries of their species range or in the central part of the species range. The 33 species out of 207 under investigation (16.0%) whose populations will primarily become threatened or will likely be at risk of extinction with a shift in range to the northeast. Accordingly, with further climate warming throughout the 21st century, about one-sixth of the species in Lithuania may be at risk of extinction. The Lithuanian breeding populations of these

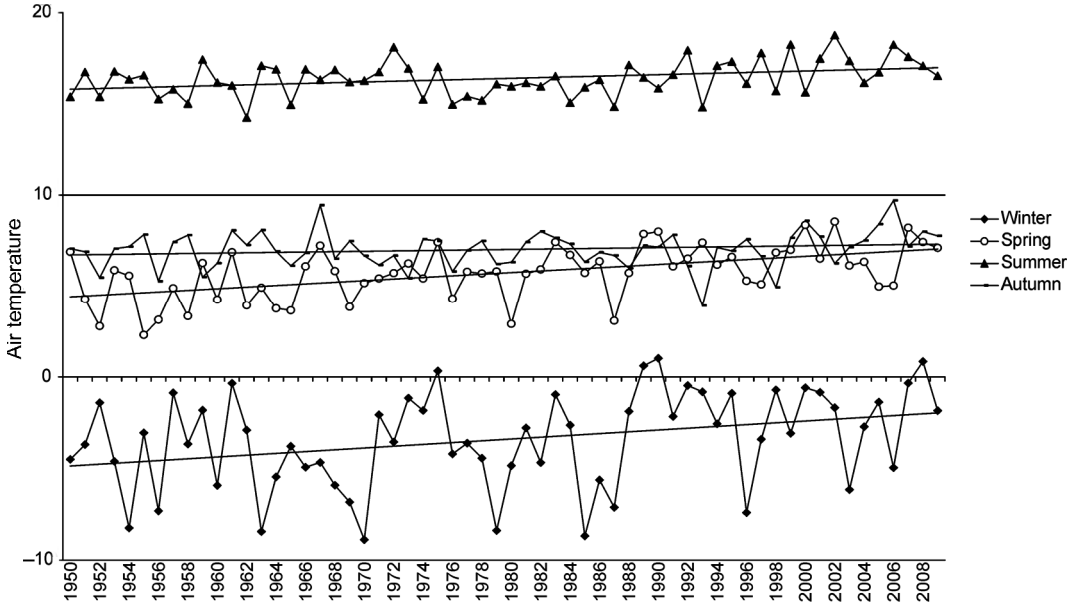

Fig. 1. Air temperature (°C) and its linear trends in Lithuania from 1950 to 2009 (the data were taken from the Archive of the Lithuanian Hydrometeorological Service)

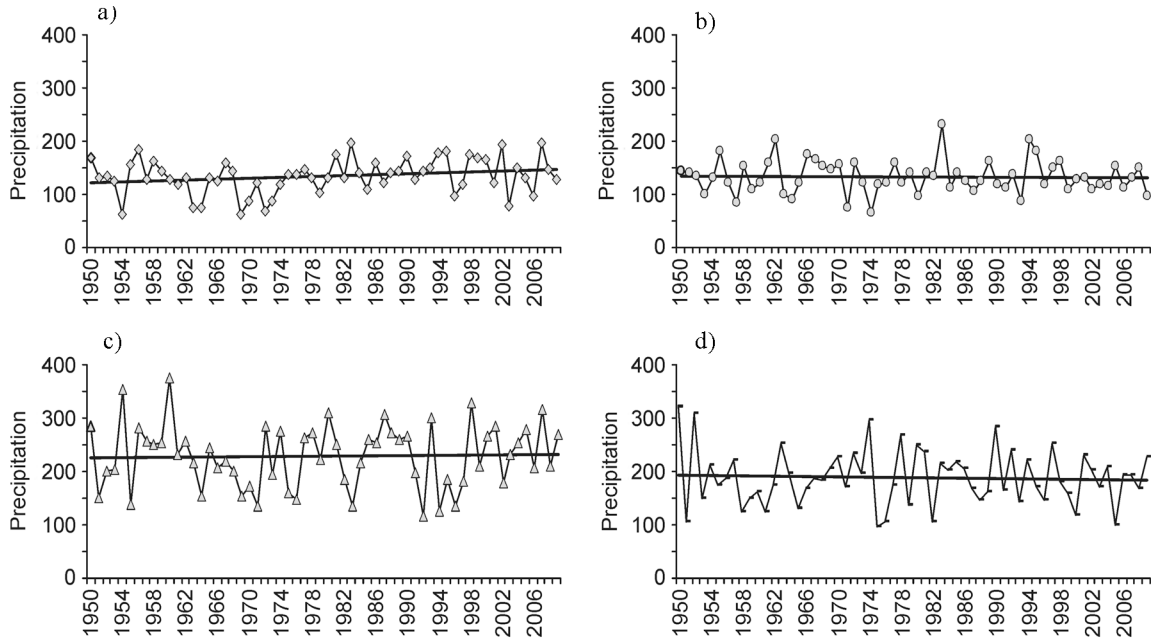

Fig. 2. Precipitation amount (mm) in winter (a), spring (b), summer (c), autumn (d) and its linear trends in Lithuania from 1950 to 2009 (the data were taken from the Archive of the Lithuanian Hydrometeorological Service)

species are on western, south-western and southern peripheries of the entire species range. Out of the 33 primarily affected and endangered species, 15 species are identified as long-distance migrants, 11 species as short- or medium-distance migrants and seven as resident. For 182 out of the 207 investigated species (87.9%) the results of our forecast coincide with the forecast presented for Lithuania by Huntley *et al.* (2007).

The analysis shows that the greatest number of species breeding on western, south-western and southern peripheries of the entire species range was found in freshwater (36.4%), wet open and semi-open (30.3%) and wet woodland (21.2%) habitats (Table 1). The least number of such species is in dry open and semi-open (3.0%) and dry woodland (9.1%) habitats. The greatest number of species breeding on the north-western, northern, north-eastern, eastern peripheries and in the central part of the entire species range was found in dry woodland (28.7%), freshwater related (23.0%) and dry open and semi-open (22.4%) habitats. The least number of such species is in wet woodland (10.9%) and in wet open and semi-open (15.0%) habitats (Table 1). It is obvious that in different peripheries of ranges, the proportion of greatest numbers of species differs in wet and dry habitats.

Of Lithuanian all species breeding in wet habitats, less species (17) breed on the southern, south-western,

Table 1. Basic characteristics of species (n=207) vulnerability projections for 5 main groups of habitats

				continuity of population range in number of analysed species			
				at possible risk of extinction*		likely surviving*	
	at possible risk of extinction (in S-SW-W peripheries of species range)	not coinciding with Huntley *et al.* (2007) forecast	likely surviving (in NW-N-NE-E peripheries and in the central part of species range)	R	C	R	C
open and semi-open wet, 36	10 (30.3%)	4 (16.0%)	26 (15.0%)	10	0	7	19
woodland wet, 26	7 (21.2%)	7 (28.0%)	19 (10.9%)	6	1	3	16
freshwater related, 52	12 (36.4%)	10 (40.0%)	40 (23.0%)	11	1	22	18
woodland dry, 53	3 (9.1%)	3 (12.0%)	50 (28.7%)	1	2	5	45
open and semi-open dry, 40	1 (3.0%)	1 (4.0%)	39 (22.4%)	1	0	10	29
total, 207	33 (100.0%)	25 (100.0%)	174 (100.0%)	29	4	47	127

* – according to our projection
R – analysed population in the restricted parts or patches of ranges – outside the boundaries of the entire range of species
C – analysed population in the continuous species range

western peripheries of the species ranges and more species (45) are found breeding in the central part or on the northern, north-eastern, eastern peripheries of ranges, whereas in dry habitats we observe the situation – four species breed on southern, south-western, western peripheries of species ranges and 89 species breed in the central part or on the northern, north-eastern, eastern peripheries of ranges (Fig. 3; significant difference is shown by Log linear analysis of frequency tables: $\chi^2 = 16.97$; df = 1, P<0.001).

Freshwater habitats are characterized by a high number of species both "at possible risk of extinction" and "likely surviving". Consequently species breeding in freshwater habitats were not included into further analysis. They require additional special studies.

Of Lithuanian species breeding in wet habitats and having a restricted and patchily distributed range in the region, more species (16) breed on the southern, south-western, western peripheries of the species ranges and less species (10) are found breeding in the central part or on the northern, north-eastern, eastern peripheries of ranges, whereas in dry habitats we observe the opposite situation – two species breed on southern, south-western, western peripheries of species ranges and 15 species breed in the central part or on the northern, north-eastern, eastern peripheries of ranges (Fig. 4; significant difference is shown by Log linear analysis of frequency tables: $\chi^2 = 10.46$; p<0.01).

Meanwhile, among species with continuously distributed ranges, relatively more species are found in both wet and dry habitats (four categories) breeding on the northern, north-eastern, eastern peripheries of ranges.

Hence, we can draw a conclusion that the further possible extinction of the studied bird species due to climate change is related to the position of the periphery of birds' breeding range and the breeding habitat (wet or dry). For wet habitat breeders on the southern, south-western, western periphery of ranges, the ranges for the majority of species are non-continuous (even now, as the species undergoes retreat, this tendency of non-continuity of range is observed), whereas on the northern, north-eastern, eastern periphery and in the central part of ranges, for the majority of species the ranges are continuous (this shows a tendency of spread of species). For dry habitat breeders on the southern, south-western, western periphery of ranges, very few species are found (the character of the range is complicated to describe because as a rule these are southern species), whereas on the northern, north-eastern, eastern periphery and in the central part of ranges, for the majority of species the ranges are continuous (this shows a tendency of spread of species).

Huntley *et al.* (2007) indicates that an additional 25 out of the 207 investigated species (12.1%) will retreat from Lithuania. According to our review though, these species would not become extinct in Lithuania. However, of these 25 species, the Lithuanian breeding populations of 15 species (60%) are in isolated patches of ranges or beyond the boundaries of the continuous species range. These species may primarily become vulnerable and endangered. Notwithstanding, out of these 25 species, the Lithuanian breeding populations of 21 species (84%) are in the central, northern and north-eastern parts of the entire species range and thus would not become extinct in Lithuania. Of these, 13 out of the 25 species are long-distance migrants; nine are short/medium-distance migrants and three resident or sedentary.

Of course here we must stress that the impact of climate warming is not the only factor and other population limiting factors (first of all – human activity – as a major additional factor apart from natural population limiting factors) must be always taken into consideration (Baltrėnas, Zagorskis 2008; Zvankus *et al.* 2008; Povilaitis, Querner 2008; Lukianas, Ruminaitė 2009).

Climate's impacts on the distribution of species have implications with respect to extinction risk (Huntley *et al.* 2007) and to future biodiversity patterns (Lovejoy and Hannah 2005).

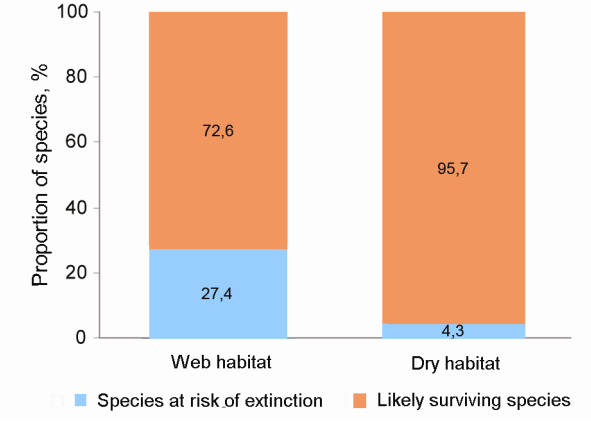

Fig. 3. Vulnerability projection of all bird species in two types of habitats (wet and dry)

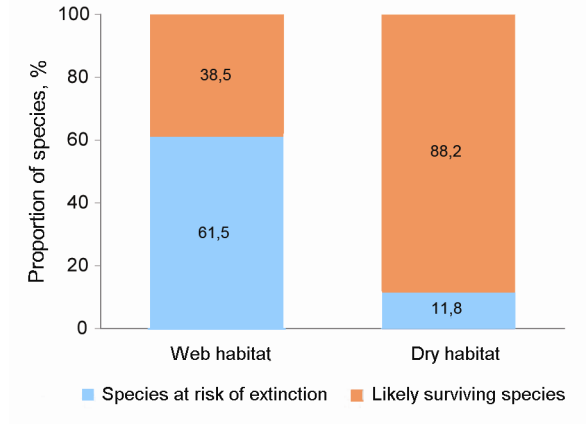

Fig. 4. Vulnerability projection of bird species having restricted and patchily distributed ranges in two types of habitats (wet and dry)

As different range limiting factors vary so much, the impact of climate change on breeding populations of birds differs in different parts of the species range (Žalakevičius 1999). Of course, winter cold cannot have a direct influence upon the breeding distribution of migrant species. However, indirectly winter temperature may determine the distribution of suitable habitats for species and availability and abundance of food supplies through its impact upon resident insects and other organisms that comprise these supplies. In a similar way, moisture supply is unlikely to have a direct impact upon many bird species, but indirectly the influence is obvious in the same manner as winter temperature (Huntley *et al.* 2007). Moisture availability strongly determines the distribution of plant species, the character of vegetation, thus indirectly determining habitat availability for birds. Also, moisture availability determines the quality and quantity of plant-derived food supplies available to birds (fruits, seeds, vegetative plant parts). Moisture availability correlates with soil moisture and abundance and availability of soil invertebrates (Huntley *et al.* 2007). As climate warms, many shallow wetlands and moist grasslands may dry up or stay wet for shorter periods, making them less suitable habitats for waterfowl, waders and moist habitat related passerine bird species (Smart, Gill 2003; Glick 2005). Temporal, seasonal and semi-permanent wetlands, along with other semi-waterlogged (rather moist) habitats, are particularly affected. They are of particular importance for a vast range of ecological and systematic groups of bird species (Kaminski, Weller 1992). Also, these are habitats for the majority of Lithuanian bird species which will be affected by climate change as predicted by the authors (Table 1). Elsewhere the decline in numbers of breeding water and moist habitat birds usually closely corresponds to losses of water amount in their surroundings due to climate impacts (Cowardin *et al.* 1995; Sorenson *et al.* 1998; Thompson *et al.* 2008). Raised bogs which are exceptionally dependent on precipitation water are particularly sensitive to climate change (Ruseckas, Grigaliūnas 2008). Due to negative climate change impact on raised bogs, alternative breeding habitats for specialised species will cease to exist (Smart, Gill 2003). In Lithuania, wood sandpiper *Tringa glareola* and Eurasian golden plover *Pluvialis apricaria* – wet open habitat species, whose possible extinction is predicted by our model - are known to breed only in raised bogs.

Due to climate change, not all species suffer or become extinct in a definite territory (Žalakevičius 2007). Thus in Belarus, 27 new breeding bird species were recorded during the past 100 years, 25 of which were recorded in the past 50 years. 69.2% of species have spread from the south. 84% of species are closely connected to water bodies or wetlands. A rapid extension of typical species of steppe avifauna occurred between 1970 and 1990 (Nikiforov 1997). In Latvia, of the nesting 186 species of Lake Engure 18 species have appeared as newcomers (56% of southern and 6% of northern origin), 10 species have ceased nesting (60% of northern, 10% of southern origin) over the last 50 years (Viksne *et al.* 2005). These changes are explained by climate warming.

The north and north-eastward shift of the distribution range of species characteristic of western, south-eastern and southern Europe registered in Lithuania throughout the 20th century (great cormorant *Phalacrocorax carbo*, great white egret *Egretta alba,* mute swan *Cygnus olor*, common shelduck *Tadorna tadorna*, gadwall *Anas strepera*, common pochard *Aythya ferina*, tufted duck *Aythya fuligula,* pied avocet *Recurvirostra avosetta*, Eurasian oystercatcher *Haematopus ostralegus*, whiskered tern *Chlidonias hybridus,* red kite *Milvus milvus*, collared dove *Streptopelia decaocto,* penduline tit *Remiz pendulinus* and European serin *Serinus serinus*) was probably mainly caused by impact of the climate change in Europe (Kurlavičius 2006; Žalakevičius 2007). The establishment of great white egret as a breeding species in Lithuania reflects a rapid sizeable northward range expansion of this species characteristic of the Mediterranean/Black Sea region during the last decades (Fig. 5) (Švažas *et al.* 2010). The north-eastward range expansion of this species can be primarily ascribed to the climate change in the main distribution range. The recorded northwards range expansion of this southern species was much faster than that predicted by Huntley *et al.* (2007). The breeding range of mute swan in the eastern Baltic region has expanded up to 2000 kilometres to the north-east during the last 50 years, with an average range

expansion of 50 km per year (Nikiforov *et al.* 1997; Švažas 2001).

A northward contraction in the breeding range during the 20th century was recorded for dunlin *Calidris alpina,* Eurasian golden plover, dotterel *Charadrius morinellus,* whimbrel *Numenius phaeopus*, turnstone *Arenania interpres* and jack snipe *Lymnocryptes minimus* (Kurlavičius 2006). These species still breed sporadically in Lithuania or other Baltic States, but their distribution ranges have moved to northern European boreal and arctic regions. During the last decades the breeding range of jack snipe has markedly contracted in the Baltic region, but simultaneously its range expansion was recorded in tundra zone of Northern Europe (Fig. 6) (Švažas *et al.* 2010).

Fig. 5. Range expansion of Great Egret (*Egretta alba*)

Fig. 6. Change of the breeding range of Jack Snipe (*Lymnocryptes minimus*)

According to our review, with the range moving in the north-eastern direction one-sixth of populations of species in Lithuania may be the first to decrease, become threatened or possibly retreat and become extinct. The Lithuanian breeding populations of these species are on the western, south-western and southern peripheries of the entire range of species. The results coincide (87.9%) with the forecast for Lithuania made by Huntley *et al.* (2007). These authors forecast the extinction of 25 more species from Lithuania, although our review does not suggest such evidence. In case the forecast presented by Huntley *et al.* (2007) proved correct, about 28% of breeding species populations may be at the greatest risk of extinction in Lithuania. Other species, whose populations in Lithuania are on the northern, north-eastern, eastern and north-western peripheries or in the central part of species ranges, are likely to benefit from the situation in the process of climate warming. The bird diversity, population state, richness and composition of communities currently observed in Lithuania reflect the present climatic situation in this region and a clear indication to bird adaptation. Our investigations corroborate with the results obtained by other authors. Retreats of some northern species from their southernmost sections of breeding ranges and extensions to the north to the breeding ranges of many southern species are indicated in several publications (Tomiałojć 1990; Brommer 2004; Viksne *et al.* 2005). On the other hand, the obtained results which show a general tendency can have exceptions (Nikiforov 1997; Viksne *et al.* 2005).

Our results show that breeding in wet habitats, patchiness of the breeding range and breeding on the southern, south-western and western peripheries of the entire species range are directly interconnected and, when combined with climate warming throughout the 21st century, may cause the greatest risk of extinction for Lithuanian breeding populations. By contrast, breeding in dry habitats, a continuity of species breeding range and the breeding on north-western, northern, north-eastern and eastern peripheries and in the central part of the species range may not induce a risk of extinction for Lithuanian breeding populations under climate warming conditions.

Climate change, intensification of land use and land abandonment jointly affect bird communities (MacDonald *et al.* 2000; Rounsevel *et al.* 2006). Intensification of land use led to collaps of farmland avifauna in West Europe (Donald *et al.* 2001). However, as in the case of climate impact, species with northerly ranges and long-distance migrants are more sensitive (Lemoine *et al.* 2007). On other hand, 7 species of global concern in Europe are vulnerable to land abandonment (Tucker and Heath 1994). Once again, as in case with climate change, species on southern edge of their range may benefit from land abandonment and forest recovery, while species on northern peripheries may by threatened (Suarez-Seoane *et al.* 2002).

Apart from species decline and possible extinction, climate warming also induces new processes in ecosystems, such as the spread of new southern species, changing bird diversity and changing steady interrelations in communities and ecosystems. Sometimes it poses new ecologi-

cal problems and new threats to local species and communities. Undoubtedly, especially alarming is the much higher speed of the recent climate change as compared to the expected rate, plus the growing anthropogenic loading, an increasing number of man-made barriers across the species shifting areas, the increasing nefarious usage of natural resources and a growing intrusion to ecosystems. Thereby, bird diversity variation under the impact of climate change is a serious problem facing the world and we must find a new environmental politics in overall and effective measures of bird protection in particular.

4. Conclusions

1. The bird diversity, population state, richness and composition of communities currently observed in Lithuania reflect the present climatic situation in the region.

2. With climate change progressing at the rate forecasted by climatologists in the future the response of bird species to climate warming may not be uniform.

3. With the range moving in the north-eastern direction five-sixth of populations of species in Lithuania are likely to benefit from the situation and may not retreat in the process of climate warming. Populations of these species in Lithuania are on the northern, north-eastern, eastern and north-western peripheries or in the central part of species ranges.

4. With the range moving in the north-eastern direction one-sixth of populations of species in Lithuania may be the first to decrease, become threatened or possibly retreat and become extinct. Populations of these species in Lithuania are on the western, south-western and southern peripheries of the entire range of species.

5. Species breeding in wet habitats, patchiness of the breeding range and breeding on the southern, south-western and western peripheries of the entire species range are directly interconnected and, when combined with climate warming throughout the 21st century, may cause the greatest risk of extinction for Lithuanian breeding populations.

6. Bird diversity variation under the impact of climate change is a serious problem facing the world and we must find a new approach in designing effective measures of bird protection and management.

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GALIMO KLIMATO KAITOS POVEIKIO PAUKŠČIŲ RŪŠINEI SUDĖČIAI SVARBA KURIANT EFEKTYVIUS PAUKŠČIŲ APSAUGOS IR PAUKŠČIŲ RŪŠIŲ REGULIAVIMO BŪDUS (RYTŲ BALTIJOS REGIONO PAVYZDŽIU)

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Santrauka

Apžvalga parodė, kad iš 207 Lietuvoje perinčių paukščių rūšių, jų arealams traukiantis šiaurės rytų kryptimi, 33 (16 %) rūšių populiacijoms, perinčioms rūšies arealo vakarinėje, pietvakarinėje ir pietinėje periferijose, gresia pažeidimai, jos gali išnykti. Su įvairiomis buveinėmis susijusios rūšys gali patirti skirtingą žalą, iš jų labiausiai pažeidžiamos šlapiosiose buveinėse perinčios rūšys. Sausųjų buveinių bendrijų galimai pažeidžiamų rūšių skaičius, priešingai, mažiausias. Kitoms 174 rūšims (84 %), kurių perinčios populiacijos yra rūšies arealo šiaurinėje, šiaurės rytinėje, rytinėje ir šiaurės vakarinėje periferijoje ir arealo centrinėje dalyje, klimato šilimas gali turėti teigiamos įtakos, tad jos neturėtų išnykti. Nustatyta, kad perėjimo arealo fragmentiškumas, paukščių perėjimas šlapiuosiuose biotopuose bei rūšies arealo vakarinėje, pietvakarinėje bei pietinėje periferijose yra tarpusavyje artimai susiję, ir, klimatui 21 amžiuje toliau šylant, šios Lietuvoje perinčios rūšys turėtų patirti didžiausią išnykimo pavojų. Be to, klimato kaita nėra vienintelis rūšių išnykimo pavojus, nes čia veikia ir kiti veiksniai, tokie kaip žemėnaudos pokyčiai. Paukščių įvairovės kaita keičiantis klimatui visame pasaulyje aktuali problema. Būtina ieškoti sprendimų, kaip sumažinti paukščiams kylantį pavojų, atsižvelgiant į rūšių biotopų pasirinkimo ekologijos specifiškumą, regioninius klimato kaitos pokyčius ir mastą, siekti pasirinkti efektyvius paukščių apsaugos ir paukščių rūšių reguliavimo būdus.

Reikšminiai žodžiai: arealų slinktis, rūšių išnykimo pavojus, klimato kaita, aplinkos politika.

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