EKOLOGIJA. 2007. Vol. 53. No. 1. P. 1–9

Climate-induced alterations in the Lithuanian migratory avifauna: regional and species-specific aspects

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The article demonstrates that the impact of climate change on breeding populations of birds differs in different parts of the species range and in different migratory categories. The majority of migrants breeding in the central part of the range or on its northern, north-eastern, eastern and south-eastern periphery benefit from climate change and their range extends. On the southern, south-western, western and north-western periphery of the species range only the short- and medium-distance migrants benefit from climate warming, whereas the population state of long-distance migrants deteriorates. Thus, alterations in the composition of avifauna in the eastern Baltic region occur at the expense of long-distance migrants. The article introduces a new approach to threats faced by birds and a new vision of their protection, stressing the importance of the knowledge of the migratory status of breeding birds, the population location within the entire species range as well as the trends and scope of the regional climate change in designing effective measures and ways of bird protection.

Key words: central and peripheral populations, breeding ranges, avifauna, species composition

INTRODUCTION

It was only two decades ago that the impact of global climate change (Berthold, 1990, 2002; Bairlein, Winkel, 2001; McCarty, 2001; Žalakevičius, 2001; Julliard et al., 2004; Böhning-Gaese, Lemoine, 2004) with its still undetermined scope (Møller et al., 2004) was recognised as another important complex factor alongside the direct anthropogenic impact. Therefore, investigations of this kind are urgent and necessary.

Climate change creates ideal conditions for a 'natural experiment' which is currently taking place. This 'experiment' enables us (also physiologists, biogeographers, etc.) to approach the already established and recognised regularities anew. Now, the majority of links established in ecosystems in the course of evolution under previously more stable environmental conditions can be observed within a narrower range of their possible variations than the evolutionary acquired range of potential adaptations allows. Climatic fluctuations of the last decades make it possible to approach, test and establish the dynamics of phenomena anew within a broader spectrum than under normal conditions. That is especially important when modelling the processes of animate nature: models developed under particular stable conditions are not always applicable under changing conditions. A broader spectrum of conditions, occasionally reached extreme conditions that are beyond the bound of possibilities (threshold of possibilities) enable scientists to observe phenomena in their new quality. That is one of the reasons why ecologists, biologists and environmentalists have taken interest in mechanisms of climate change impact and a great number of recently conducted investigations, printed studies and modelling-based prognoses illustrate that (McCarty, 2001; Julliard et al., 2004; Møller et al., 2004; Thomas et al., 2004). In spite of that, there is still a shortage of such investigations (Böhning-Gaese, Lemoine, 2004; Møller et al., 2004).

This article discusses the impact of climate change on the population state of birds in Lithuania (Central Europe) in the conditions of the recently relatively constant and decreasing anthropogenic pressure. An attempt is made to reveal differences in the impact climate change has on Lithuanian breeding short-, medium- and long-distance migrants in different parts of their species breeding ranges. The article puts forward and tests the hypothesis that climate change has a different impact on migratory bird populations of different categories depending on various parts of their species range. It elucidates the mechanisms of climate change impact on the avifauna composition and on the shift of breeding ranges. Consequently, a novel vision of bird protection is presented.

MATERIALS AND METHODS

To conduct this study, the information on Lithuanian breeding species with the known population trends and population location within the entire species range (i. e. the Lithuanian breeding population may be in the central or peripheral part of the species range) was selected and newly updated. The study covered only sufficiently abundant and common species with the known population numbers and the known trends of the previous fifty/fifteen years (the last period was selected due to more pronounced climate warming in the region). The state of a population is estimated by experts as its tendency to increase, to stay stable or to decrease over indicated periods. Such evaluation of the population state was selected as we lack more precise information on quantitative classification criteria of population trends in the region. For that purpose, sets of long-term data on bird numbers, the population state and its trends in Lithuania in the second half of the 20th century as well as the newly published material containing information on Lithuanian birds (Ivanauskas, 1957, 1959, 1964; Logminas, 1990, 1991; Balevičius, 1992; Žalakevičius et al., 1995; Snow, Perrins, 1998; Švažas et al., 1999; Burfield, Bommel, 2004; Papazoglou et al., 2004; Kurlavičius, 2006) and other kinds of scientific information including long-term monitoring data presented by experts and stored on a database in the Laboratory of Avian Ecology of the Institute of Ecology of Vilnius University were used. Changes in bird population state, induced by increasing climate change in the eastern Baltic region over the last fifteen years (1990–2005) in comparison to the last fifty-year period, were taken into consideration. The continually updated database includes 321 bird species, 215 of which breed or formerly bred in Lithuania. Only 33 of all the bird species covered by the study are increasing in number, whereas 46 are declining and 83 are stable. The data on the remaining 53 species are scarce, because the species are rare or insufficiently studied. The research on the impact of climate change on the breeding bird population state was conducted on 162 species, excluding uncommon species and species with insufficient data. The study did not include sparse species, species with insufficient information on their abundance and those with the unknown population state and change trends. For the identification of the position of Lithuanian breeding populations in the entire species range, the latest and the most precise data on the distribution of breeding birds in the whole Western Palearctic were used (Snow, Perrins, 1998). The position of populations breeding in the central or a particular periphery of the species range was localised by comparing the Lithuanian population with the entire species range.

To check the reliability of the difference in the population state of different bird groups in different locations within the species range, the chi-square distribution test was used (Statistica 6 package for Microsoft Windows 2000).

RESULTS

Climate in the region during the period under investigation has been changing considerably. Since the 1970s, positive spring temperature deviations have become dominant, and since 1988 positive spring and summer temperature deviations have prevailed (Fig. 1). In the series of spring air temperatures for the period 1950–1971, negative temperature anomalies were observed more often (14 out of 22, i. e. 64%), whereas positive anomalies prevailed (27 out of 33, i. e. 82%,) from 1972 to 2004. Mean spring temperature anomalies were –0.8 °C for 1950–1971 and +0.5 °C, $p < 0.001$ for 1972–2004. A similar pattern was observed in summer temperatures: negative anomalies for 1950–1987 made up 58% (22 out of 38) and positive anomalies for 1988–2004 amounted to 65% (11 out of 17). Mean summer temperature anomalies for 1950–1987 were –0.3 °C, whereas for 1987–2004 they were +0.5 °C, $p < 0.0001$ (Žalakevičius et al., 2006b).

Great variations in winter, spring and summer precipitation levels were recorded during the study period (Fig. 2). A statistically significant linear trend reveals an increase in winter precipitation since 1950 ($y = 3.5807\times - 100.15$; $R^2 = 0.0467$; $p < 0.02$). No clear variation tendencies in spring and summer precipitation series were observed, precipitation deviations shifted around the long-term mean. The linear precipitation trend during the cold period (NOV–MAR) in Lithuania was significant ($y = 3.7522\times + 1718.8$; $R^2 = 0.03$; $p < 0.001$) and showed an increase in precipitation since 1950. During warm seasons (APR–OCT) since 1950, a decrease in precipitation was recorded, but the linear trend was not significant ($y = -2.6419\times + 3308.6$; $R^2 = 0.0045$; $p < 0.65$) (Žalakevičius et al., 2006b).

To assess the impact of climate change on the state of our different migratory regional bird populations, a total of 162 Lithuanian breeding bird species were studied, two of them being nomadic, 26 residents, and 134 various migrants (Table 1). It is known that in Lithuania a great part of populations of southern, south-western, western, north-western (hereafter – southern) bird species are increasing in abundance, whereas those of northern, north-eastern, eastern and south-eastern (hereafter northern) species are decreasing (Table 1, Annex 2, Žalakevičius, 2001).

In the process of data analysis, the hypothesis was formed that populations of various types of migrants (short/medium- and long-distance) are differently affected by climate warming in different parts of the species range. Analysis of 134 bird species breeding in Lithuania allowed us to evaluate the state of populations of short-, medium- and long-distance migrants in both central and peripheral parts of their species ranges (Tables 1, 2, Annex 2). It has been concluded that as a result of climate change, populations of long-distance migrants breeding in the southern periphery of the species range tend to decline, whereas those of short- and medium-

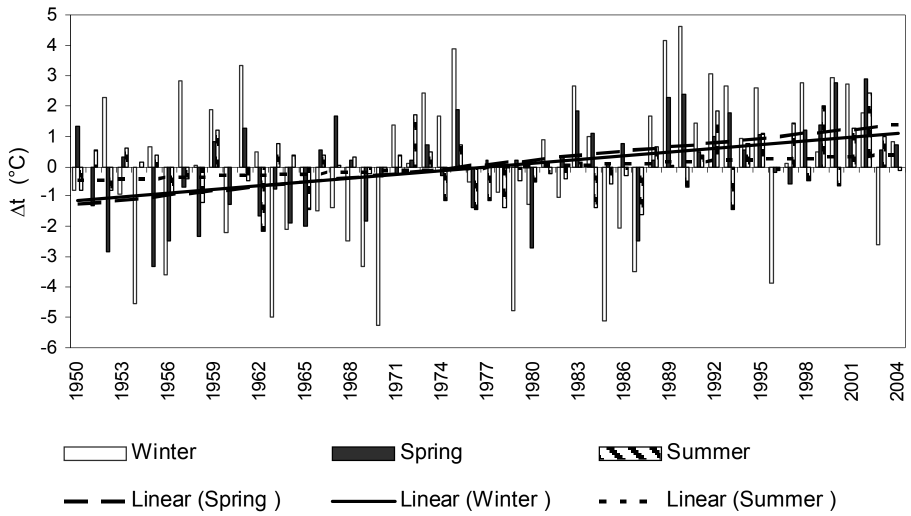

Fig. 1. Air temperature anomaly (Δt, °C) and linear trends in Lithuania, 1950–2004

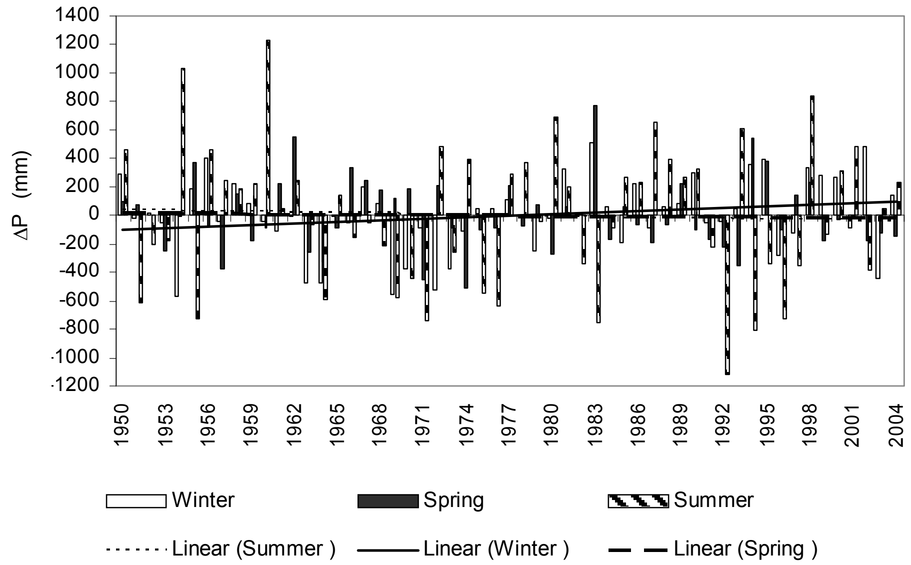

Fig. 2. Precipitation anomaly (ΔP, mm) and linear trends in Lithuania, 1950–2004

Table 1. **Population state of Lithuanian breeding bird populations in relation to differences in migratory status and breeding ranges (n = 162)**

Migrant type	Northern-northeastern-eastern-southeastern part			Central part			Southern-southwestern-western-northwestern part		
	Increasing	Stable	Decreasing	Increasing	Stable	Decreasing	Increasing	Stable	Decreasing
Short- and medium- distance	6	1	2	8	25	3	3	11	3
Long-distance	2	2	0	6	23	6	3	10	20
Resident	–	1	4	4	6	4	–	3	4
Vagrant	–	–	–	–	1	–	1	–	–
Total	8	4	6	18	55	13	7	24	27

Table 2. **Population state of bird species breeding in the southern, south-western, western and north-western parts of the species breeding range within Lithuania (n = 57)**

Migrant type	Increasing	Stable	Decreasing
Short-, medium-distance and resident	3	11	3
Long-distance	3	10	20
Total	6	21	23

Annex 1. **Lithuanian breeding birds in the central part (n = 86) of the species range (species of the Red Data Book of Lithuania are indicated in bold; S – short- and medium-distance migrant; L – long-distance migrant; R – resident; V – vagrant)**

Population state		
Increasing	Stable	Decreasing
Cygnus olor (S)	*Buteo buteo* (S)	*Ardea cinerea* (S)
Aythya fuligula (S)	***Pernis apivorus* (L)**	*Perdix perdix* (R)
Grus grus (L)	*Columba palumbus* (S)	*Dryocopus martius* (R)
Circus aeruginosus (L)	*Podiceps cristatus* (S)	*Hirundo rustica* (L)
Turdus merula (S)	*Delichon urbica* (L)	*Anthus pratensis* (S)
Saxicola rubetra (L)	*Accipiter gentilis* (S)	*Locustella fluviatilis* (L)
Corvus corone (R)	*Accipiter nisus* (S)	*Ficedula parva* (L)
Corvus corax (R)	*Anas platyrhynchos* (S)	*Lanius collurio* (L)
Columba livia (R)	*Emberiza citrinella* (R)	*Passer domesticus* (R
***Falco tinnunculus* (S)**	*Lullula arborea* (L)	*Columba oenas* (S)
Pyrrhula pyrrhula (S)	*Luscinia luscinia* (L)	*Locustella naevia* (L)
Apus apus (L)	*Phoenicurus phoenicurus* (L)	*Muscicapa striata* (L)
Motacilla alba (S)	*Oenanthe oenanthe* (L)	*Certhia familiaris* (R)
Turdus pilaris (S)	*Rallus aquaticus* (L)	
Acrocephalus scirpaceus (L)	*Charadrius dubius* (L)	
Ficedula hypoleuca (L)	*Vanellus vanellus* (S)	
Garrulus glandarius (S)	*Gallinula chloropus* (S)	
Pica pica (R)	*Fulica atra* (S)	
	Alauda arvensis (S)	
	Sylvia curruca (L)	
	Sylvia borin (L)	
	Scolopax rusticola (S)	
	Fringilla coelebs (S)	
	Cuculus canorus (L)	
	Strix aluco (R)	
	Asio otus (S)	
	Caprimulgus europaeus (L)	
	Jynx torquilla (L)	
	Dendrocopos major (R)	
	Dendrocopos minor (R)	
	Riparia riparia (L)	
	Anthus trivialis (L)	
	Troglodytes troglodytes (S)	
	Prunella modularis (S)	
	Erithacus rubecula (S)	
	Turdus philomelos (S)	
	Acrocephalus schoenobaenus (L)	
	Acrocephalus palustris (L)	
	Acrocephalus arundinaceus (L)	
	Hippolais icterina (L)	
	Sylvia atricapilla (L)	
	Phylloscopus sibilatrix (L)	
	Phylloscopus collybita (L)	
	Phylloscopus trochilus (L)	
	Regulus regulus (S)	
	Aegithalos caudatus (S)	
	Parus montanus (R)	
	Parus cristatus (R)	
	Parus caeruleus (V)	
	Parus major (S)	
	Sturnus vulgaris (S)	
	Carduelis chloris (S)	
	Carduelis cannabina (S)	
	Carduelis spinus (S)	
	Emberiza schoeniclus (S)	
Total species: 18	Total species: 55	Total species: 13

Annex 2. **Lithuanian breeding birds on the peripheries of species range (n = 76; species of the Red Data Book of Lithuania are indicated in bold; S – short- and medium-distance migrant, L – long-distance migrant; R – resident; V – vagrant)**

Population state	On the N-NE-E-SE periphery of the range	On the S-SW-W-NW periphery of the range
Increasing	***Anser anser*** (S)	***Haliaeetus albicilla*** (V)
	Phalacrocorax carbo (S)	*Larus canus* (S)
	Ciconia ciconia (L)	***Porzana parva*** (L)
	Remiz pendulinus (S)	*Aythya ferina* (S)
	Phoenicurus ochruros (S)	***Coturnix coturnix*** (L)
	Charadrius hiaticula (L)	***Crex crex*** (L)
	Corvus frugilegus (S)	*Larus argentatus* (S)
	Serinus serinus (S)	
Stable	***Tyto alba*** (R)	*Botaurus stellaris* (**S**)
	Locustella luscinioides (L)	*Bucephala clangula* (S)
	Sylvia nisoria (L)	***Aquila pomarina*** (L)
	Coccothraustes coccothraustes (S)	***Glaucidium passerinum*** (R)
		Picus canus (R)
		Turdus viscivorus (S)
		Sylvia communis (L)
		Pandion haliaetus (L)
		Falco columbarius (S)
		Mergus merganser (R)
		Mergus serrator (S)
		Tringa ochropus (L)
		Larus minutus (S)
		Chlidonias leucopterus (L)
		Alcedo atthis (S)
		Podiceps grisegena (S)
		Gavia arctica (S)
		Larus ridibundus (S)
		Chlidonias niger (L)
		Calidris alpina (**L**)
		Gallinago gallinago (S)
		Motacilla flava (L)
		Falco subbuteo (L)
		Limosa limosa (L)
Decreasing	*Streptopelia decaocto* (R)	*Nucifraga caryocatactes* (S)
	Passer montanus (R)	***Circus pygargus*** (L)
	Tadorna tadorna (S)	*Bonasa bonasia* (R)
	Parus palustris (R)	***Tetrao tetrix*** (R)
	Sitta europaea (R)	*Anas crecca* (S)
	Tachybaptus ruficollis (S)	*Actitis hypoleucos* (L)
		Tetrao urogallus (R)
		Anas clypeata (L)
		Porzana porzana (L)
		Pluvialis apricaria (L)
		Gallinago media (L)
		Lymnocryptes minimus (L)
		Philomachus pugnax (L)
		Numenius arquata (L)
		Tringa totanus (L)
		Acrocephalus paludicola (L)
		Tringa glareola (L)
		Podiceps nigricollis (S)
		Ixobrychus minutus (L)
		Ciconia nigra (L)
		Anas querquedula (L)
		Milvus migrans (L)
		Sterna hirundo (L)
		Sterna albifrons (L)
		Streptopelia turtur (L)
		Coracias garrulus (L)
		Dendrocopos leucotos (R)

distance are stable or growing. The chi-square was calculated for two groups of species (short-, medium-distance migrants versus long-distance migrants) with the state of their populations: increasing, stable and decreasing. The chi-square test confirmed the existence of a correlation between the migratory status of a bird species and its population state (increasing, stable and decreasing; $\chi^2 = 8.35$, $p < 0.02$; increasing/stable and decreasing; $\chi^2 = 8.33$, $p < 0.005$; Table 2). This kind of regularity is not observed for species whose populations in Lithuania are central or northern peripheral (Table 1). Thus, the results support the conclusion that on the southern periphery of the range, short- and medium-distance migrants benefit from climate warming, whereas the population state of long-distance migrants deteriorates. This proves that the alteration in the avifauna structure of migrants in the eastern Baltic region is taking place at the expense of long-distance migrants breeding on the southern periphery of the species range. Populations of long-distance migrants breeding at the southern edge of the species range are decreasing, leaving space or resources to populations of short- and medium-distance migrants.

DISCUSSION

Recent investigations indicate an evident impact of climate warming on animate nature and bird populations in various continents (Rheinwald, 1994; Burton, 1995; McCarty, 2001; Walther et al., 2002; Sokolov, Payevsky, 1998; Mineev, 1999; Dunn, Winkler, 1999; Peter, 1999; Bairlein, Winkel, 2001; Žalakevičius, Žalakevičiūtė, 2001; Berthold, 2002; Sokolov, Kosarev, 2003; Böhning-Gaese, Lemoine, 2004; Lehikoinen et al., 2004; Chambers et al., 2005; Huntley et al., 2006; Žalakevičius et al., 2006a; Žalakevičius et al., 2006b). Climate change is the cause of an important and rapid reduction and / or increase in the population size of several common species (Julliard et al., 2004; Chambers et al., 2005; Huntley et al., 2006).

According to the data of Lithuanian climatologists, the climate in the country is getting warmer (winter and spring temperatures are rising) and drier (the amount of precipitation during the warm period of the year is decreasing) (Žalakevičius et al., 2006b). Consequently, climate change has an evident impact on successive changes of habitats and feeding conditions in the region. Thus, long-term meteorological data obviously support our attempts to explain changes in the composition of bird communities or avifauna in the region, taking into account the fact that recently (the period of the last 15 years) the conditions of anthropogenic pressure (especially agricultural activity) have been relatively constant or decreasing. It is logical that climatic conditions for a bird species are usually optimal in the central part of its geographical range, conditions in the periphery being less favourable (Timofeev-Resovskij et al., 1973; Krebs, 1985; Hengeveld, 1994). Our investigations indicate that the population state of the majority of bird species breeding in the eastern part of the Baltic region as well as its change trends are significantly affected by the recent 15 year more pronounced climate change in the region. The difference in the impact on different parts of the species range shows that bird ranges are shifting northwards (or north-eastwards) in the region. Populations of northern species are withdrawing, while southern populations are arriving to the region. As a result, the composition of avifauna is changing. Similar results were also reported by authors from Western Europe (Johnson, 1994; Thomas, Lennon, 1999; Pounds et al., 1999; Peterson, 2003; Julliard et al., 2004; Chambers et al., 2005), as well as the neighbouring countries: northern Latvia (Viksne, 2000; Viksne et al., 2005) and southern Belarus (Nikiforov, 2003). According to Viksne (2000), '... species of southern origin prevailed among newcomers, while those of northern origin among extinct species. Especially marked changes were observed from 1992/1993 to the late 1990s. It is likely that climatic warming of the recent decade is becoming one of the major factors determining the bird population state and the bird range shift'. Apart from the impact of climate warming, other factors such as successive changes of habitats and feeding conditions, predation, disturbance and other unknown reasons have to be considered as limiting factors to the populations (Viksne, 2000; Viksne et al., 2005). Nikiforov (2003) shows that a rapid growth in numbers and habitats of steppe avifauna representatives took place in Belarus in 1970–1990; 69.2% of species spread from the south. This author suggests that shifts of ranges can be caused by several other factors or mechanisms besides the climatic impact. Interactions with other species and population dynamics are of no less importance in predicting shifts in species ranges (Davis et al., 1998).

Changes in the composition of bird or avifauna communities were also reported from Central Europe (Berthold, 1990, 1998, 2002; Bairlein, Winkel, 2001; Böhning-Gaese, Lemoine, 2004). Different authors explain this phenomenon by increasing sedentariness and population density of birds, decrease in mortality rates of short- and medium-distance migrants, and earlier arrival of birds (at the beginning of the spring arrival season) enabling them to occupy better territories (Berthold, 1990; Bairlein, Winkel, 2001; Švažas et al., 2001).

Our investigations have revealed that climate change in the eastern Baltic region has a different impact on short-, medium-, and long-distance migrants. The results indicate that the majority of migrants breeding in the central part or on the northern periphery of the species range benefit from climate change, their populations remaining either stable or increasing. Meanwhile, populations of long-distance migrant species breeding on the southern periphery of the species range are decreasing. Populations of short- and medium-distance migrants breeding on the southern periphery of the species range are increasing or stable. So, the obtained results suggest that the alteration in the composition of breeding avifauna in Lithuania is mainly influenced by changes in populations of long-distance migrants breeding in the southern part of the species range. The latter is not reported by other authors. Although trends towards the population decrease of long-distance migrants were recorded (Berthold, 1990), the population state of these migrants was not related to the population location within the species range. Based on our results, we can claim that climate-change-induced alterations in the composition of avifauna or in bird communities are not a universal process: it is a spatial and a species-specific process. Other authors (Bairlein, Winkel, 2001; Lemoine, Böhning-Gaese, 2003; Chambers et al., 2005), reporting a decline in the proportion of long-distance migrants in European avian communities, also note that the climate change impact is species-specific. However, these authors do not give an answer to the question what role a particular periphery of the range plays in the response of a particular population to climate change.

Finally, we must stress that recent conservation strategies give climate-change-induced impacts little consideration (Hannah et al., 2002). Consequently, to devise effective measures of bird protection, it is necessary to consider the location of the breeding birds' population within the species range, the status of birds, the species-specific ecology of habitat selection and the scope of regional climate change, at least from two of their main aspects: temperature change and precipitation (aridisation) affecting birds through successive changes of habitats and feeding conditions. The fact that climate change impact on birds varies with different phases of the annual cycle must not be forgotten either. Under the conditions of climate change, protection of long-distance migrants on the southern edge of their range is becoming inexpedient: it is necessary to look for the replacement of protected areas for them in the regions further to the north. The necessity for a more effective international co-operation and border-free protection arises. On the other hand, more optimal conditions in the central or northern part of its range make species protection easier. Baltic countries having joined the EU and the NATURA 2000 network of protected territories having been legalised, it is necessary to take climate change factors into consideration so as to increase the efficiency of protected areas, to preserve habitats and species for future generations. It is important when devising management plans, conservation actions, measures, programmes and creating the NATURA 2000 network of protected areas. Therefore, it is necessary to revise the current protection strategy and policy, adjusting them to particular territories of the regions. Otherwise, the predicted future decline of species will not be curbed.

The results obtained are important to different sectors of human activity, science, nature protection and management. So, the still existing gaps in the information on the climate change impact on bird distribution, abundance and various stages of bird life cycle are still topical and require further research.

ACKNOWLEDGEMENTS

I thank Dr M. Dagys, Dr S. Švažas, Dr V. Stanevičius and Mr L. Raudonikis from the Laboratory of Avian Ecology of the Institute of Ecology of Vilnius University for their assistance in evaluating the population state of Lithuanian breeding birds as well as for valuable comments and proposals. Many thanks to Dr Franz Bairlein, Dr Peter Berthold and Dr Anders P. Møller for the invitation to join several special conferences and workshops and cooperation enabling me to prepare this paper. Research was carried out by the Institute of Ecology of Vilnius University and it complies with current laws of The Republic of Lithuania.

Received 11 September 2006
Accepted 15 February 2007

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KLIMATO SĄLYGOTI LIETUVOS MIGRANTŲ ORNITOFAUNOS POKYČIAI: REGIONINIAI IR RŪŠIŲ SPECIFIŠKUMO ASPEKTAI

Santrauka

Straipsnyje parodyta, kad klimato kaitos poveikis perinčių paukščių populiacijoms nevienodas tiek įvairiose rūšių perėjimo arealo vietose, tiek skirtingose migrantų kategorijose. Dauguma migrantų, perinčių rūšių arealo centrinėje dalyje ar arealo šiaurės, šiaurės rytų, rytų ir pietryčių periferijose, nenukenčia keičiantis klimatui bei plečia savo arealus. Rūšių perėjimo arealų pietinėje, pietvakarinėje, vakarinėje ir šiaurės vakarinėje periferijose perintys artimieji ir vidutinio nuotolio migrantai klimatui keičiantis nenukenčia, tuo tarpu tolimųjų migrantų populiacijos nukenčia. Taigi rytų Baltijos regiono ornitofaunos struktūros pokyčius iš esmės lemia tolimųjų migrantų populiacijos būklė. Paukščių apsaugos būdams ir priemonėms efektyvinti straipsnyje pateikiamas naujas požiūris į paukščiams gresiančius pavojus bei jų apsaugą, panaudojant žinias apie perinčių paukščių migracinį statusą, jų užimamą vietą rūšies perėjimo areale, klimato kaitos regione kryptis bei mastą.

Raktažodžiai: centrinės ir periferinės populiacijos, perėjimo arealai, ornitofauna, rūšinė sudėtis