Ekológia (Bratislava) Vol. 28, No. 3, p. 291–299, 2009
doi:10.4149/ekol_2009_03_291

EFFECT OF FLOODING ON PALEARCTIC MIGRANT BIRDS AT THE EILAT STOPOVER SITE IN ISRAEL

PIOTR ZDUNIAK[1*], REUVEN YOSEF [2], PIOTR TRYJANOWSKI [3]

[1] Department of Avian Biology & Ecology, Faculty of Biology, Adam Mickiewicz University, Umultowska 89, PL-61-614 Poznań, Poland; e-mail: kudlaty@amu.edu.pl
[2] International Birding & Research Centre in Eilat, P.O. Box 774, Eilat 88106, Israel; e-mail: ryosef@eilatcity.co.il
[3] Institute of Zoology, Poznań University of Life Sciences, Wojska Polskiego 71 C, PL-60-625 Poznań, Poland; e-mail: piotr.tryjanowski@gmail.com

Abstract

Zduniak P., Yosef R., Tryjanowski P.: Effect of flooding on Palearctic migrant birds at the Eilat stopover site in Israel. Ekológia (Bratislava), Vol. 28, No. 3, p. 291–299, 2009.

Recently, populations of long-distance migrant birds breeding in temperate regions and wintering in tropical Africa have shown a stronger decline than short-distance migrant or resident species. Among many other factors, the situation at stopover sites can strongly influence the migratory capability of populations. By comparison with the three previous years and one subsequent year, here we present information of how a single catastrophic event, the great flood early in spring 2006, destroyed an ecosystem at the globally recognized and important stopover point at Eilat, Israel. Overall, during the five spring migration seasons a total of 33 293 individuals of 103 passerine bird species were recorded. The largest number was in 2005 – 80 species, then 2004 – 78, 2003 – 73 and only 68 species in 2006 and 67 in 2007. In general, the number of individuals from particular species differed between seasons and the number of birds recorded in 2006 was lower than in 2003, 2004 or 2005 and did not differ from the number obtained in 2007. Moreover there were no differences between the years 2003–2005 and 2007. However, the strongest effect was noted for species that winter only in Africa.

Key words: birds, flood, migration, stopover site, Israel, population decline

Introduction

There is evidence that populations of long-distance migrant birds breeding in temperate regions and wintering in tropical Africa, have declined in recent decades at a greater rate than those of short-distance migrants and resident species (Sanderson et al., 2006).

* Corresponding author

A number of possible causes have been forwarded for the observed population declines of migrants, mainly habitat loss (Pimm, Raven, 2000) on the wintering and/or breeding grounds (Wilson, Cresswell, 2006). It has recently been suggested by Lemoine et al. (2007), that habitat changes, coupled with climate change, play a role in the decline of long-distance migrants in the breeding areas. However, this study like many others focuses only on a local (breeding) situation, and does not address the wintering and migratory aspects of the life cycle. In order to rectify the situation, data from the wintering grounds and stopover sites are also to be considered a priority. Recent studies have been undertaken in Africa in order to understand the importance of the wintering areas to Palearctic migratory populations (Newton, 2004; Sanderson et al., 2006). However, there is information lacking on the critically located stopover sites along migratory routes, even though the importance of these aspects for migrant populations and their migration capabilities has long been emphasized (e.g. Frumkin et al., 1995; Newton, 2004). There are a limited number of studies that consider the importance of stopover sites, but they have focused mainly on the importance of improving migratory fuel deposition before and after crossing ecological barriers such as high mountains, seas and deserts (e.g. Biebach, 1995; Frumkin et al., 1995). For example, all Eurasian breeding bird populations that winter in sub-Saharan Africa have to cross the Saharan-Saudi Arabian Desert belt. Most passerines cross the desert on a broad front, however with higher densities in the eastern and western parts of the Sahara desert belt (Biebach, 1995). A great proportion of these birds stop at Eilat, since it is the last favorable stopover area for migratory birds during autumn before crossing the Sahara on their way to East Africa, or in the spring is the first stopover site after their crossing of the desert barrier (Safriel, 1968; Frumkin et al., 1995; Shirihai, 1996; Yosef, Tryjanowski, 2002a, b, c). Therefore, the ecosystem destruction of such an important stopover site like Eilat could have drastic consequences for many Palearctic migrant species. Obviously, habitat changes have natural and/or human origin, and the negative influence of human pressure on migrants is relatively well known (e.g. hunting, habitat destruction). However, natural changes in habitats may have even stronger effects.

Early in the spring of 2006, the Eilat region was flooded and many habitats important for resting birds were destroyed (Fig. 1). Hence, a sort of a "natural experiment" was forced upon us for analysis. In this article we present data of the effect of the flood damage on the traditional staging migrants. In the framework of the catching and ringing program of the International Birding and Research Centre in Eilat (IBRCE) we had the opportunity to compare our catching success during the spring in 2006 with results obtained from previous years and the following year. We paid special attention to long-distance (African) migrants, resident species, and those species that winter in the Eilat region. We focused on how different groups of migrants react to erratic and stochastic habitat changes. Habitat quality, or in a general sense the "environment", can influence not only the population size of migrants, through reduced survival connected to the limited food resources, but also can affect timing of migration, stopover duration, and their continued migration to their breeding grounds across Europe and Asia.

Fig. 1. Views of marshes (top panel) and shrubs (bottom panel) commonly used by migratory birds before (left panel) and after (right panel) the catastrophic flood on 3 February 2006. Note the large quantity of clay deposited by the receding waters.

Material and methods

Trapping and banding of birds has been conducted at the International Birding and Research Center (IBRCE) in Eilat, Israel (29°33'N, 34°57'E), in the 68-hectare Bird Sanctuary (see Yosef, Tryjanowski, 2002c). Eilat is located at the southernmost tip of Israel and lies within the Saharo-Arabian desert, characterized by extreme temperatures and very low precipitation (average annual rain 17 mm).

On Friday 3rd of February 2006 at 5.00 AM heavy rain occurred, and as a result of 23 mm of rain in northern Saudi Arabia, a flash flood swept through Jordan and washed through the lower Arava valley. The flood plain to the north of the Jordanian city of Aqaba, on the eastern shores of the Gulf of Aqaba/Eilat, is protected by dams. As a result the water is channeled directly towards the international boundary in an unnatural manner resulting in a much more severe flash flood, than would naturally occur. The flooding on the Israeli side of the border included the border crossing with Jordan, the agricultural fields of Kibbutz Elot and the IBRCEs' Bird Sanctuary. Evidence from the number of trapped birds showed that wintering birds were present and the spring migration had already started. The fresh water lake (Anita lake) located at the heart of the Bird Sanctuary burst its banks as the deluge flooded into it. Large quantities of mud and clay remained, and the freshwater ecosystem of the lake was temporarily completely destroyed. All of the high ground was covered with more than 30 cm of mud that destroyed low vegetation and shrubs and severely damaged the irrigation system to the rest of the 9000 trees planted as a food source for the bird populations. Afterwards only limited action was initiated to restore the Bird Sanctuary and return it to its original condition, which favored the large early March migration waves. In spring 2007 – one year after the catastrophic flood – the situation is back to normal, although some of the shrubs and vegetation cover destroyed by the water are not yet restored to their previous size.

Data for this study were collected in the normal process of the research program conducted at the IBRCE ringing station since 1984. In this study we analyzed data from spring passage collected between March and June. However, only data from the years 2003–2007 were selected for comparison for two reasons: 1. catching effort was uniform during this period; 2. to understand what happened in spring 2006 compared to a more general migration situation in the years immediately previous to and after the incident.

Catching

Analyzed data were collected during five spring migration seasons in the years 2003–2007 and we limited ourselves to passerine species. Birds were trapped during the day only using 8 Helgoland traps with 32×6 m entrances. All trapped bird species were identified, ringed, aged and, where possible, also sexed (Svensson, 1992).

Data processing and analysis

Owing to the fact that the flood of spring 2006 was of a very destructive character and all habitat types in the region were destroyed to some extent, we interpreted changes in population size (number of caught birds) and phenology (time) of migration of selected species by comparison with data from the three previous years and one year after the flood as a reference period. Therefore this is a spontaneous natural experiment. Thus this experiment is without a control for the same period of the same year.

We analyzed for possible differences between the five spring migration seasons, which concerned the number of species caught and the number of recorded individuals from each of the species using a chi-square test and repeated measures ANOVA, respectively. As regards the number of species, the analysis includes all passerine species. Passerines were divided into species wintering in Israel, and others that winter in Africa only. Furthermore, we selected 12 of the most numerous of the trans-Saharan migrants (Table 1) and analyzed possible differences in arrival time in Julian dates between the five years of study. This was done separately for each species. Because phenology of migration besides a year can also be affected by different age and sex categories of birds (e.g. Tryjanowski, Yosef, 2002; Yosef, Tryjanowski, 2002a, for the Eilat stop-over point), we analyzed the simultaneous effect of year, age and sex (when possible) on the dependent variable using factorial ANOVA. If the analyzed factorial system was incomplete (e.g., in a given year juvenile females were not recorded), the main-effects ANOVA were applied. Additionally, to avoid pseudoreplication, only data of first caught birds during the season were used in our analyses that related to differences in size and arrival time of the migratory bird populations.

Standard statistical methods were used to describe and analyze the data (Sokal, Rohlf, 1995). The calculations were performed using STATISTICA for Windows (StatSoft Inc., 2005). All statistical tests were two-tailed. Throughout the text, mean values are presented with their standard error (SE). Because in this paper we made several multiple comparisons, significance levels were corrected by the false discovery rate (FDR, the proportion of false discoveries) method, proved to better compromise between type I and II errors (Benjamini, Hochberg, 1995; Waite, Campbell, 2006).

Results

Number of species and individuals

Overall, during the four spring migration seasons a total of 33293 individuals of 103 passerine bird species were recorded. The largest number was in 2005 – 80 species, then 2004 – 78, 2003 – 73 and only 68 species in 2006 and 67 in 2007. However, the number of species recorded did not differ significantly between years (chi-square = 0.92, df = 4, P = 0.92).

In general, the number of individuals from a particular species differed between seasons (repeated measurements ANOVA, $F_{4,408} = 5.00$, $P < 0.001$). The number of birds recorded in 2006 was lower than in any of the previous three years (HSD Tukey test, in all cases $P < 0.009$). No differences were found between the years 2006 and 2007 and the years 2003–2005 and 2007 (in all cases $P > 0.2$, Fig. 2). Furthermore, significant differences in bird numbers were found when we analyzed for species that winter only in Africa ($F_{4,256} = 3.72$, $P = 0.006$). They concerned only two years, when the number of birds caught in 2004 was significantly higher than in 2006 (HSD Tukey test, in all cases $P < 0.007$). No such difference was found for the species that winter only in Israel ($F_{4,84} = 1.03$, $P > 0.40$). An analysis conducted for bird species recorded in numbers of over 100 individuals during five years of the study gave very similar results.

T a b l e 1. The analyzed trans-Saharan migrant species with total numbers of birds caught and numbers of individuals identified to the age and/or sex classes during the four spring seasons at Eilat, Israel. Because of lack of visual sexual dimorphism in several species, classification to sex is not complete.

No.	Species	No. of birds caught	No. of complete determined birds	Juveniles			Adults		
				total	male	female	total	male	female
1.	*Sylvia atricapilla*	12953	12846	8917	4186	4731	3929	1901	2028
2.	*Sylvia communis*	511	440	185	101	84	255	125	130
3.	*Sylvia hortensis*	399	362	248	144	104	114	52	62
4.	*Sylvia melanocephala*	175	166	67	56	11	99	56	43
5.	*Lanius nubicus*	401	390	187	106	81	203	142	61
6.	*Hirundo rustica*	892	789	132	48	84	657	296	361
7.	*Riparia riparia*	989	987	468			519		
8.	*Delichon urbica*	212	212	74			138		
9.	*Hippolais pallida*	1235	1223	255			968		
10.	*Phylloscopus bonelli*	521	512	156			356		
11.	*Acrocephalus scirpaceus*	560	554	162			392		
12.	*Anthus trivialis*	246	246	113			133		

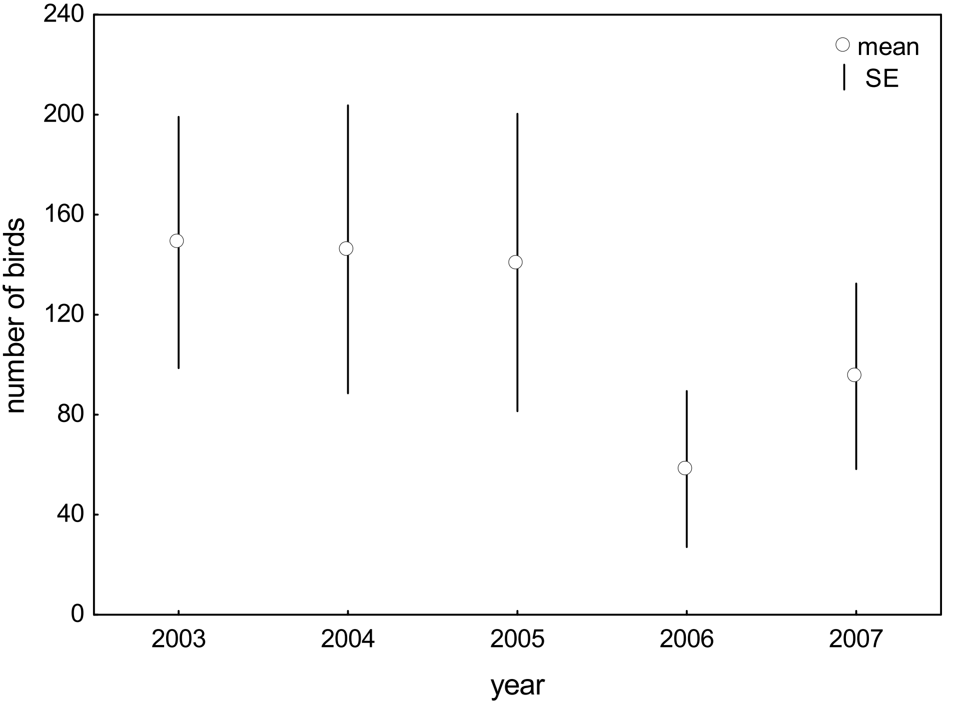

Fig. 2. Differences in the number of individuals trapped per season during the five spring migrations at Eilat, Israel.

Migration phenology

In 9 of the 12 species analysed, we found a significant effect of year on phenology. However, only in the case of the blackcap *Sylvia atricapilla*, masked shrike *Lanius nubicus* and olivaceous warbler *Hippolais pallida* did the phenology for 2006 differ significantly from previous years (factorial ANOVA, $F_{4,12826} = 266.71$, $P < 0.001$, $F_{4,370} = 12.26$, $P < 0.001$) and two-way ANOVA, $F_{4, 1217} = 48.51$, $P < 0.001$, respectively), and birds were caught significantly earlier (HSD Tukey test, $P < 0.005$, $P < 0.001$ and $P < 0.03$; all significant after FDR correction for multiple testing). On the other hand, in 2007, blackcaps were recorded even earlier than in 2006 (HSD Tukey test, $P < 0.001$) but no such differences were found in the case of masked shrikes and olivaceous warblers (in both cases $P > 0.36$).

Recapture probability of migrants

The analysis of the 12 most numerous migratory species showed slight differences in the mean probability of birds being recaptured between analyzed seasons (repeated measurements ANOVA, $F_{4,44} = 2.67$, $P = 0.044$). However, the differences between years expressed by post-hoc HSD Tukey test were non significant for all comparisons ($P > 0.056$ in all cases).

Discussion

Our results show that even sporadic catastrophic events like a flash flood can affect birds during spring in Eilat, Israel. Interestingly, our findings illustrate that in the months after the floods the long-distance trans-Saharan migrants were more influenced than the resident or short-distance migrants that overwinter in the Eilat region. Long-distance migrants appear to be more sensitive to drastic environmental changes because they use species-specific stopover sites (Fransson et al., 2005), and after a stochastic event such as the flash flood, they turn up at their traditional sites and do not have the time or physiological resources to look for alternative staging areas in the arid zones. Although we are able to show an effect of a flash flood on migratory birds, but the real effect may be even greater, because bird populations as well as the overall ecosystem responses to catastrophic events may be delayed (Knopf, Sedgwick, 1987; Scheffer et al., 2001).

Presented here is an example of how desert flash floods could change and reshape semiarid ecosystems (Scheffer et al., 2001; Hice et al., 2006). Interestingly, in our case the catastrophic event is not the result of precipitation in the study area, but a consequence of water transport from the precipitation epicenter located tens of kilometers away.

Our data show that the flood affected not only the total numbers of birds staging during the spring migration, but also may have influenced other parameters including phenology and stopover duration (measured as probability of recapture), although these effects were generally small. The latter are probably both crucial for the health and survival of the migratory populations (Webster et al., 2002; Ahola et al., 2004; Newton, 2004). For three species (25% of more detailed analyzed species) in spring 2006 we recorded earlier migration time than in any of the previous three years. The delay in Eilat could be a result of catching probability – devastated habitats do not offer enough resources for the populations. This results in a shorter stopover, which obviously results in lower trapping probability, and as a consequence, this affects the detected time of migration. Moreover, this is also partially supported by the low (although only in direct comparison to spring 2004) number of retraps in 2006. This measure, however, works only partially, because generally during the spring migration birds have low recapture probability (Tryjanowski, Yosef, 2002; Yosef, Tryjanowski, 2002a), and estimating this factor has broad confidential limits.

Our study is of special interest, because there are not many studies showing the real-time effects of flash floods on staging capabilities of migratory birds. It is important to understand how such catastrophic events influence ecosystems and passerine migrants in specific cases. It also allows us to take these parameters into account for long term conservation planning. Although desert flash floods are very intermittent (Dayan, Abramski, 1983; our data) they can have a prolonged negative influence on birds and their habitats, and can have stronger cumulative impacts in the future. This is especially true owing to our present awareness of the effects of climate change and the increasing number of severe events world wide such as tsunamis, typhoons, cyclones, and floods (Kundzewicz, Schellnhuber, 2004; Hice et al., 2006).

Translated by the authors

Acknowledgements

We thank ICA in Israel, Disney Fast Response Fund, L. Mitchell and B. Bausch for their support of the IBRCE; and the hundreds of interns and students who have helped at the ringing station. V. Takacs and L. Carroll commented on earlier versions of the manuscript.

References

Ahola, M., Laaksonen, T., Sippola, K., Eeva, T., Rainio, K., Lehikoinen, E., 2004: Variation in climate warming along the migration route uncouples arrival and breeding dates. Global Change Biology, *10*: 1610–1617. doi:10.1111/j.1365-2486.2004.00823.x

Benjamini, Y., Hochberg, Y., 1995: Controlling the false discovery rate: A practical and powerful approach to multiple testing. Journal of the Royal Statistical Society B, *57*: 289–300.

Biebach, H., 1995: Stopover of migrating flying across the Mediterranean Sea and the Sahara. Isr. J. Zool., *41*: 387–392.

Dayan, U., Abramski, R., 1983: Heavy rain in the Middle East related to unusual jet stream properities. Bulletin of the American Meteorological Society, *64*: 1138–1140. doi:10.1175/1520-0477(1983)064<1138:HRITME>2.0.CO;2

Fransson, T., Jakobsson, S. Kullberg, C., 2005: Non-random distribution of ring recoveries from trans-Saharan migrants indicates species-specific stopover areas. J. Avian Biol., *36*: 6–11. doi:10.1111/j.0908-8857.2005.03471.x

Frumkin, R., Pinshow, B., Kleinhaus, S., 1995: A review of bird migration over Israel. Journal of Ornithology, *136*: 127–147. doi:10.1007/BF01651235

Hice, C., Jaksic, F., Kelt, D.A., Letnic, M., Lima, M., López, B.C., Meserve, P.L., Milstead, W.B., Polis, G.A., Previtali, M.A., Richter, M., Sabaté, S., Squeo, F.A., 2006: Extreme climatic events shape arid and semiarid ecosystems. Frontiers in Ecology and the Environment, *4*: 87–95. doi:10.1890/1540-9295(2006)004[0087:ECESAA]2.0.CO;2

Knopf, F.L., Sedgwick, J.A., 1987: Latent population responses of summer birds to a catastrophic, climatological event. Condor, *89*: 869–873. doi:10.2307/1368536

Kundzewicz, Z.W., Schellnhuber, H.J., 2004: Floods in the IPCC TAR perspective. Natural Hazards, *31*: 111–128. doi:10.1023/B:NHAZ.0000020257.09228.7b

Lemoine, N., Schaefer, H.Ch., Böhning-Gaese, K., 2007: Species richness of migratory birds is influenced by global climate change. Glob. Ecol. Biogeogr., *16*: 55–64. doi:10.1111/j.1466-8238.2006.00252.x

Newton, I., 2004: Population limitation in migrants. Ibis, *146*: 197–226. doi:10.1111/j.1474-919X.2004.00293.x

Pimm, S.L., Raven, P., 2000: Extinction by numbers. Nature, *403*: 843–845. doi:10.1038/35002708

Safriel, U., 1968: Bird migration at Elat, Israel. Ibis, *110*: 283–320. doi:10.1111/j.1474-919X.1968.tb00039.x

Sanderson, F.J., Donald, P.F., Pain, D.J., Burfield, I.J., van Bommel, F.P.J., 2006: Long-term population declines in Afro-Palearctic migrant birds. Biol. Conserv., *131*: 93–105. doi:10.1016/j.biocon.2006.02.008

Scheffer, M., Carpenther, S., Foley, J.A., Folke, C., Walker, B., 2001: Catastrophic shifts in ecosystems. Nature, *413*: 591–596. doi:10.1038/35098000

Shirihai, H., 1996: The birds of Israel. Academic Press, London, 876 pp.

Sokal R.R., Rohlf, F.J., 1995: Biometry. 3rd ed. Freeman, New York, 887 pp.

StatSoft, Inc. 2005. STATISTICA (data analysis software system), version 7.1. http://www.statsoft.com

Svensson, L., 1992: Identification guide to European passerines. Lullula, Stockholm.

Tryjanowski, P., Yosef, R., 2002: Differences between the spring and autumn migration of the Red-backed Shrike Lanius collurio: record from the Eilat stopover (Israel). Acta Ornithol., *37*: 85–90.

Waite, T.A., Campbell, L.G., 2006: Controlling the false discovery rate and increasing statistical power in ecological studies. Ecoscience, *13*: 439–442. doi:10.2980/1195-6860(2006)13[439:CTFDRA]2.0.CO;2

Webster, M.S., Marra, P.P., Haig, S.M., Bensch, S., Holmes, R.T., 2002: Links between worlds: unraveling migratory connectivity. Trends Ecol. Evol., *17*: 76–83. doi:10.1016/S0169-5347(01)02380-1

Wilson, J.M., Cresswell, W., 2006: How robust are Palearctic migrants to habitat loss and degradation in the Sahel? Ibis, *148*: 789–800. doi:10.1111/j.1474-919X.2006.00581.x

Yosef, R., Tryjanowski, P., 2002a: Differential spring migration of Ortolan Bunting Emberiza hortulana by sex and age at Eilat, Israel. Ornis Fenn., *79*: 173–180.
Yosef, R., Tryjanowski, P., 2002b: Spring migration ecology of the Crzetzschmar's Bunting (Emberiza caesia) through Eilat, Israel. Isr. J. Zool., *48*: 149–153. doi:10.1560/XYUW-T78Y-WHRF-1M44
Yosef, R., Tryjanowski, P., 2002c: Avian species saturation at a long-term ringing station – a never-ending story? Journal of the Yamishina Onrnithological Institute, *34*: 89–95.