POLISH JOURNAL OF ECOLOGY (Pol. J. Ecol.)	57	4	817–820	2009

Research note

Zdravko DOLENEC

Department of Zoology, Faculty of Science, University of Zagreb, Rooseveltov trg 6, HR-10000 Zagreb, Croatia, e-mail: dolenec@zg.biol.pmf.hr

IMPACT OF LOCAL AIR TEMPERATURES ON THE BROOD SIZE IN STARLING (*STURNUS VULGARIS* L.)

ABSTRACT: Many papers over recent years have demonstrated long-term temporal trends in biological parameters that can only be explained by global warming. I examined the long-term trends in the brood size of Starling (*Sturnus vulgaris*) in Mokrice area (north-western Croatia). I collected data from 1977 to 2007. To investigate the effect of spring temperatures on the brood size, local air temperature was used. The significant correlation (P <0.01) between mean brood size and the year (y = – 31.403 + 0.018x) indicates that brood size (mean number of nestlings per nest) increased by 0.018 nestling per year, or 0.54 nestling over the period of the study. Correlation between brood size (mean number of nestlings per nest) and mean spring temperature was also significant (P <0.05) and regression equation (y = 4.162 + 0.07x) indicates that brood size increased by 0.07 nestling per 1°C. The correlation between mean spring air temperature and research year was significant (P <0.01). This data show that the mean May temperature has been increasing in the study area. We can conclude that Starlings in north-western Croatia are increasing their brood size and that the most likely cause is a long-term increase in spring temperatures.

With the recent climate change (*e.g.* Houghton *et al.* 2001), and the correlated effects on many organisms (*e.g.* Walther *et al.* 2002, Parmesan and Yohe 2003), temperature has been shown to play a crucial role (Crick 2004). Climate change has been located over the continents between from 40° and 70°N (Wallace *et al.* 1996). The ready response of many species to recent climate change indicates that most species have the phenotypic plasticity to cope with such change (Crick 2004). Many bird species have earlier arrival dates (*e.g.* Dunn and Winkler 1999, Kralj and Dolenec 2008). Some have moved their former northernmost limit for nesting (*e.g.* Thomas and Lennon 1999) and a number of bird species have earlier timing of breeding (*e.g.* Sergio 2003, Dolenec *et al.* 2009). Most studies look at migratory behaviour and egg-laying performance. However, few studies have analysed long-term reproductive success. Some papers have indicated increase in brood size (*e.g.* Hušek and Adamík 2008), with authors attributed to change in local temperatures. According to Sokolov (2006), natural selection over hundreds of thousands of years should have provided for the genetic structure of populations that allows their timely restructuring and adaptation to continuously changing environmental factors such as climates. Predicting reproductive success responses to scenarios of global change is challenging. Many studies have been conducted at northern latitudes. Evidence of an avian response to climate change from more southerly latitudes has so far been lacking. I examined how a hole-nesting (Dolenec *et al.* 2008) and short-distance migrant (Dolenec 1994) the Starling *Sturnus vulgaris* has responded to recent global warming, using data from long-term study in north-western Croatia.

A nestbox-breeding populations of Starling was studied during 1977–2007 in the village of Mokrice (45°00´N, 15°55´E; north-western Croatia). The altitude of the study area is about 140 m above sea level. Oak (*Quercus robur*) and hornbeam (*Carpinus betulus*) were the dominant tree species of small isolated forest. The shrub cover is formed by common eder (*Sambucus nigra*) and black-thorn (*Prunus spinosa*). All records used in this study were from nestboxes. All *ca* 100 nestboxes were put up in trees, 2.5 to 5.0 m above the ground in an area with mixed farming and small isolated forests. The internal dimensions of the nestboxes were 160 × 160 × 250 mm, and the front section had a 45 to 50 mm diameter hole. All nestboxes had a sliding top to enable observers to monitor nesting. In this study, I showed how data from ringing records of Starling nestlings are usable for the long-term monitoring of breeding changes. This method was previously used by Hušek and Adamík (2008). I used aluminium rings from the Ornithology Institute of the Academy of Sciences and Arts in Zagreb. In this population, Starlings usually produce two regular broods per year (Dolenec 1997). Only the first broods from the pairs that bred in nestboxes were analysed. I considered only nests with birds ringed prior to June for subsequent analyses. The mean number of nestlings in nest was used as the brood size parameter. To investigate the effect of spring temperatures on the brood size, I made an use of local air temperature calculated as a mean for May. Mean monthly air temperatures for May (1977–2007) for Mokrice area (measured in town Maksimir – 20 km from village of Mokrice) were provided by the Meteorological Office in Zagreb (mean = 16.0°C, SD = 1.82; range = 12.1 to 19.3°C). General statistical procedures followed the standard methods (Sokal and Rohlf 1981) and *P*-values higher than 0.05

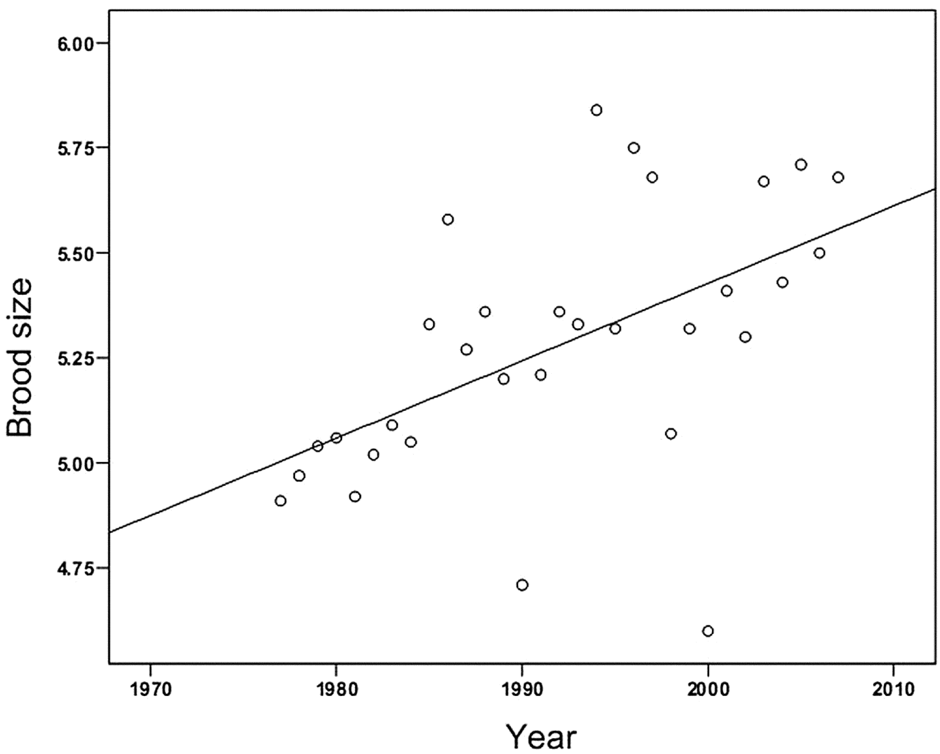

Fig. 1. Relationship between year and brood size (mean number of nestlings per nest) in Starling, 1977–2007.

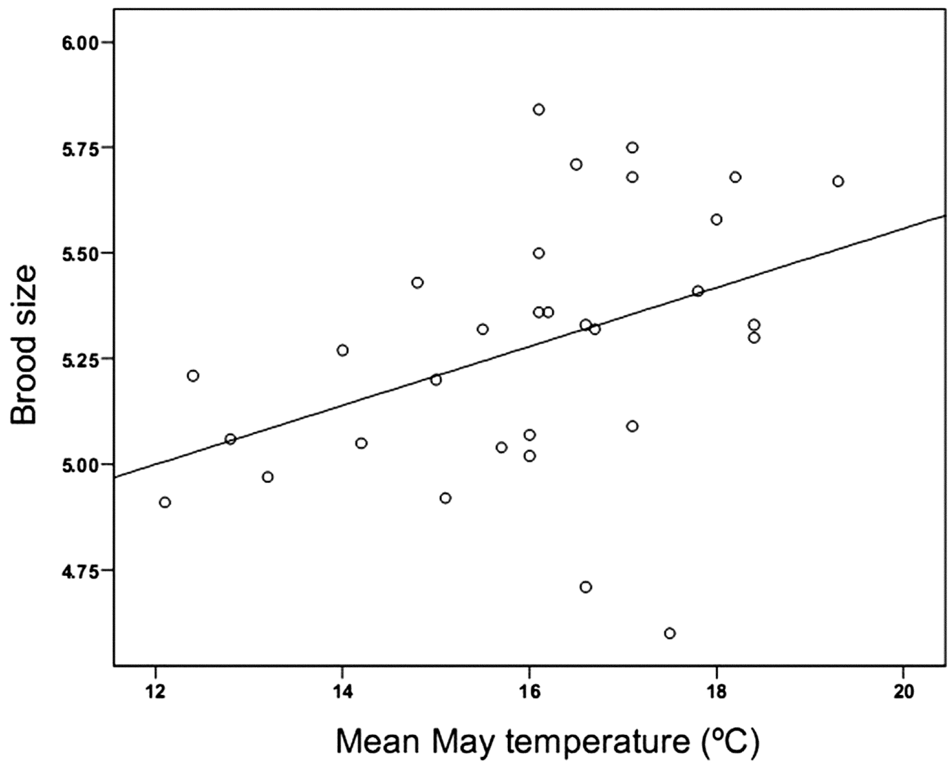

Fig. 2. Relationship between May temperatures and brood size (mean number of nestlings per nest) in Starling, 1977–2007.

were considered non-significant. Statistical analysis were performed using the SPSS 12.0 statistical package.

From 1977 to 2007, 7495 young birds in the nest were ringed (mean = 241.8 per year and mean = 5.3 per nest). I calculated Pearson`s correlation coefficient between brood size and year, and brood size and mean air temperature. There was a significant correlation between mean brood size and the year (1977–2007) (r = 0.54, *P* = 0.002, n = 31; Fig. 1). The relation between brood size and year (y = – 31.403 + 0.018x) indicates that brood size increased by 0.018 nestling per year, or 0.54 nestling over the period of the study. Correlation between brood size and mean spring temperature (mean of May values) was also significant (r = 0.41, *P* = 0.02, n = 31, Fig. 2). The regression equation was y = 4.162 + 0.07x, indicating that brood size increased by 0.07 nestling per 1°C. The correlation between mean air temperature (mean May) and research year was significant (r = 0.57, *P* = 0.001, n = 31). These data show that mean May temperature has increased in the study area. The results suggest that brood size of the Starling is influenced by spring temperatures.

Whether these birds can cope with global warming depends, to large extent, on whether they can track the advancement of their main food supplies (Both *et al.* 2004). Hence, the starlings seem to be able to respond adequately to the temporal variation in food. According to Dunn (2004), one of the biggest challenges in the future will be to predict how climate change will affect the reproductive performance of different species throughout their ranges. For example, Møller (2002) found that warmer spring were correlated with larger clutches and more competing young in the first brood, which subsequently led more recruits from first broods in the population the next year. On the other hand, Wilson and Acrese (2003) demonstrated that Song Sparrows (*Melospisa melodia*) in warmer years had more fledglings, but greater reproductive success was not associated with subsequent growth of the population. Studies of birds contributed significantly to understanding the response of animals to climate change, and they will be important in the future for monitoring and understanding the mechanistic basis for phenological change (Dunn 2004).

REFERENCES

Both C., Artemyev A.V., Blaauw B., Cowie R.J., Dekhuijzen A.J., Eeva T., Enemar A., Gustafsson L., Ivankina E.V., Järvinen A., Metcalfe N.B., Nyholm N.E.I., Potti J., Ravussian P–A., Sanz J.J., Silverin B., Slater F.M., Sokolov L.V., Török J., Winkel W., Wright J., Zang H., Visser M.E. 2004 – Large-scale geographical variation confirms that climate change causes birds to lay earlier – Proc. R. Soc. Lond. B, 271: 1657–1662.

Crick H.Q.P. 2004 – The impact of climate change on birds – Ibis, 146 (Suppl. 1): 48–56.

Dolenec Z. 1994 – Regulation migration of the autochthonous Starling, *Sturnus vulgaris*, of the Hrvatsko Zagorje region (north-western Croatia) – Riv. ital. Orn. 64: 14–20.

Dolenec Z., 1997 – Supplement to nesting habits of Starlings (*Sturnus vulgaris*) on the territory of the north-western Croatia – Larus, 46: 120–125.

Dolenec Z., Kralj J., Mustapić P., Dolenec P. 2008 – Female biometrical characteristics and egg dimensions of the Starling (*Sturnus vulgaris* L.) in Croatia – Pol. J. Ecol. 56: 545–548.

Dolenec Z., Dolenec P., Kralj J., Kiš Novak D. 2009 – Long–term trends in timing of breeding of the Barn Swallow *Hirundo rustica* in Croatia – Pol. J. Ecol. 57: 611–614.

Dunn P.O. 2004 – Breeding dates and reproductive performance – Adv. Ecol. Res. 35: 69–87.

Dunn P.O., Winkler D.W. 1999 – Climate change has effected the breeding date of the swallows throughout North America – Proc. R. Soc. Lond. B, 266: 2487–2490.

Houghton J.T., Ding Y., Griggs D.J., Noguer M., van der Linden P.J., Dai X., Maskell K., Johnson C.A. 2001 – Climate change 2001: the scientific basis – University Press, Cambridge, 94 pp.

Hušek J., Adamík P. 2008 – Long-term trends in the timing of breeding and brood size in the Red-Backed Shrike *Lanius collurio* in the Czech Republic, 1964–2004 – J. Ornithol. 149: 97–103.

Kralj J., Dolenec Z. 2008 – First arrival dates of the Naghtigale (*Luscinia megarhinchos*) to Central Croatia in the early 20 century and at the 21 century – Cent. Eur. J. Biol. 3: 295–298.

Møller A.P. 2002 – North Atlantic Oscillation (NAO) effects of climate on the relative importance of first and second clutches in a migratory passerine bird – Anim. Ecol. 71: 201–210.

Parmesan C., Yohe G. 2003 – A globally coherent fingerprint of climate change impacts across natural system – Nature, 421: 37–42.

Sergio F. 2003 – Relationship between laying dates of Black Kites *Milvus migrans* and spring temperatures in Italy: rapid response to climate change? – J. Avian Biol. 34: 144–149.

Sokal R.R., Rohlf F.J. 1981 – Biometry – Freeman & Co, New York, 859 pp.

Sokolov L.V. 2006 – Effect of global warming on the timing of migration and breeding of passerine birds in the 20th century – Entomol. Rev. 86 (Suppl 1): 59–81.

Thomas C.D., Lennon J.J. 1999 – Birds extend their ranges northwards – Nature, 399: 213.

Wallace J.M., Zhanf Y., Bajuk L. 1996 – Interpretation of interdecadal trends in Northern Hemisphere surface air temperature – J. Climate, 9: 249– 259.

Walther G.R., Post E., Convery P., Parmesan C., Beebe T.J., Fromentin J.M., Hogh–Guldberg O., Bairlein F. 2002 – Ecological responses to recent climate change – Nature, 416: 389–395.

Wilson S., Acrese P. 2003 – El Niño drives timing of breeding but not population growth in the song sparrow (*Melospiza melodia*) – Proc. Natl. Acad. Sci. USA, 100: 11139–11142.

Received after revision May 2009