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Relationship Between Atmospheric Conditions and Breeding Ecology of Tits in Artificial Nest Boxes

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Abstract: This study was conducted to investigate the relationship between atmospheric conditions and breeding ecology of *Parus* sp. tits in artificial nest boxes at a deciduous forest between March 2009 and July 2010. In order to collect data regarding tit breeding, temperature and relative humidity, researchers installed a total of 45 artificial nest boxes equipped with Hobo® Pro V2 monitors. Artificial nest boxes had one of three different entrance diameters of 30, 35 and 40 mm. The mean temperature and relative humidity in 2010 were lower than in 2009. Marsh and great tits both had differences in incubation and nestling care periods based on temperature and relative humidity during the breeding season. In addition, increases in the body weight and tarsus length of juvenile tits were slower in 2010 than in 2009. To understand whether the breeding ecology of tits is affected by atmospheric conditions, further long-term ecological research is needed.

Key words: Artificial nest boxes, breeding ecology, humidity, temperature, tits

INTRODUCTION

With the onset of climate change, there has been concern among ecologists and biologists regarding how the ecology of plants and animals might be affected (Shi *et al*., 2006). In the last decade, many researchers have investigated the effect of climatic factors on population dynamics, survival and reproduction (Crick, 2004; Laaksonen *et al*., 2006). Furthermore, while climate change can affect wildlife breeding ecology (Stevenson and Bryant, 2000), general applications for breeding success remain unclear.

Ecological variables such as food resources, predation pressure and weather conditions are all well known to influence the reproductive success and life history of bird species (Lack, 1968; Aslan and Yavuz, 2010). Clutch size, numbers of hatched and unhatched eggs, dead nestlings and fledglings are the most important variables for determining the breeding success of bird species (Lack, 1968; Cody, 1985). Moreover, it is well known that body weight and tarsus length are correlated with food availability and survival after fledgling (Perrins, 1991).

The timing of egg laying is very important for birds. Generally, colder springs result in longer incubation periods due to delayed egg laying (Cresswell and McCleery, 2003). The gee laying period of birds is roughly associated with the hatching of caterpillar eggs (Van Noordwijk *et al*., 1995). For the parents, there is selection to time reproduction so that the peak period of food demand for their offspring matches with the peak period of food resource availability (Naef-Daenzer and Keller, 1999).

Marsh tits *Parus palustris*, great tits *P. major* and varied tits *P. varius* are distributed from the Palearctic sub-region (with the exception of the tundra, steppe and desert areas) to the Far East and Northern Africa and are found in a variety of habitats including coniferous, deciduous, evergreen broadleaf and mixed forests (Lack, 1971; Eguchi, 1980; Lee *et al*., 2000). The tits of *Parus* sp. are poorly studied and thus offer an opportunity to investigate the response of breeding ecology to changes in atmospheric conditions in South Korea. Here, researchers investigated the changes in breeding ecology as measured by clutch size, incubation period, fledgling period, fledgling weight and tarsus growth of tits with respect to temperature and relative humidity in a deciduous forest >2 consecutive years.

MATERIALS AND METHODS

This study was conducted in a deciduous forest at the Ansung Campus, Chung-Ang University (37°00'N, 127°13'E), South Korea during March 2009 and July 2010. Researchers selected a study site of 120×240 m in a deciduous forest in which Mongolian oak *Quercus mongolica* and serrata oak *Q. serrata* were the dominant tree species (Rhim and Lee, 2005). The atmospheric conditions were surveyed by monitoring temperature and relative humidity. The temperature and relative humidity of deciduous forest were logged every hour using a Hobo data logger (Hobo® Pro V2, Onset Computer Corporation) (Son *et al*., 2012).

The study site was divided into 30×30 m grids marked with flags, facilitating the accurate identification of nest box location (Son *et al*., 2012). A total of 45 wooden

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artificial nest boxes (16×15×30 cm) with 1.5 cm thick walls were placed in trees 1-2 m above the ground. The artificial nest boxes included entrance with diameter of either 30, 35 or 40 mm to accommodate the different body sizes of these cavity-nesting birds (Rhim *et al*., 2008).

In this study, used nest boxes were defined as boxes in which researchers observed feces or nest material in the interior of the boxes. The presence of eggs in the artificial nest boxes was used to define breeding nest boxes (LG Evergreen Foundation, 2004). For each of the nest boxes, utilization and breeding success were investigated 4-5 times per week. Briefly, the date of appearance of eggs in the nest was recorded together with clutch size. After egg laying, researchers visited the artificial nest boxes every day to determine clutch initiation date, number of breeding attempts, egg size, clutch size and breeding parameters (hatching date, unhatched and hatched eggs, dead nestlings and fledglings) (Sanz and Tinbergen, 1999; Aslan and Yavuz, 2010; Son, 2010).

The incubation period was defined as the number of days between the last egg laid and the day of the first chick hatching. Moreover, fledgling period, breeding success, body weight of chicks and tarsus length of chicks were investigated (Son *et al*., 2012). Breeding success (%) was defined as the number of nestlings left in a nest box/the number of eggs laid ×100 (Son, 2010).

The Wilcoxon rank sum test was used for the analysis of data using the SAS package program. Significance was set at $p<0.05$ for all statistical tests. All results are presented as mean±Standard Error (SE).

RESULTS

The differences in temperature and relative humidity between years were not statistically significant. However, the temperature and relative humidity of several months, especially in the early spring were different between years. Specially, the mean temperature in March was higher in 2010 (5.90±3.53°C, mean±SE) compared with 2009 (11.39±4.40°C) (Wilcoxon rank sum test, $Z = 4.58$, $p<0.005$). However, there were no differences in the mean temperatures of April to July between 2009 and 2010 (Fig. 1).

The relative humidity in March (2009, 60.03±15.48%; 2010, 69.28±12.62%) and June (2009, 81.38±10.62%; 2010, 88.52±11.27%) were higher in 2010 than in 2009. In addition, relative humidity in March and June were significantly different between 2009 and 2010 (March, $Z = -2.29$, $p<0.005$; June, $Z = -2.73$, $p<0.05$). There were no significant differences in relative humidity in April, May and July between 2009 and 2010 (Fig. 2).

Marsh tits *Parus palustris*, great tits *P. major* and varied tits *P. varius* all bred in the artificial nest boxes

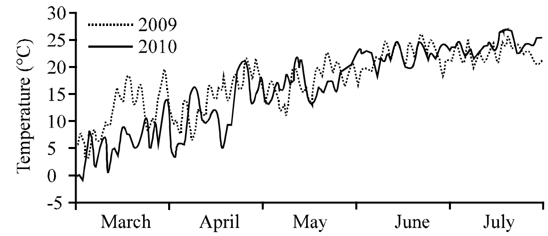

Fig. 1: Difference in the mean temperatures (°C) during tit breeding season between 2009 and 2010 at a deciduous forest, Ansung Campus, Chung-Ang University, South Korea

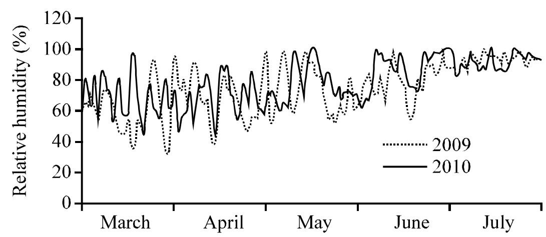

Fig. 2: Difference in the mean relative humidity (%) during tit breeding season between 2009 and 2010 at a deciduous forest, Ansung Campus, Chung-Ang University, South Korea

Table 1: Differences in the use of artificial nest boxes with different entrance diameters (mm) by tits between 2009 and 2010 at a deciduous forest, Ansung Campus, Chung-Ang University, Korea

	2009 (n =15)			2010 (n =15)		
Paramerters	30	35	40	30	35	40
No. of used artificial nest boxes	3.00	5.00	7.00	5.00	7.0	6
Used artificial nest boxes (%)	20.00	33.30	46.70	33.30	46.7	40
No. of total bred pairs	2.00	3.00	4.00	3.00	1.0	1
Breeding success (%)	33.33	29.03	38.24	51.72	0.0	0

Table 2: Number of breeding pairs of tits using artificial nest boxes with different entrance diameters (mm) between 2009 and 2010 at a deciduous forest, Ansung Campus, Chung-Ang University

	2009 (n = 15)			2010 (n = 15)		
Species	30	35	40	30	35	40
P. palustris	2	-	-	1	-	-
P. major	-	3	3	2	1	-
P. varius	-	-	1	-	-	1

during the study period. In 2009, a total 17 nest boxes were used and 9 pairs of tits bred in the nest boxes. The number of used artificial nest boxes was higher while the number of total bred pairs was lower in 2010 than in 2009 (Table 1).

There was a difference in the preference of tits for artificial nest boxes by entrance diameter in the study. Specially, marsh tits preferred the 30 mm entrance diameter. In addition, the numbers of breeding pairs of varied and great tits were higher in the 35 and 40 mm entrance diameter artificial nest boxes (Table 2).

Table 3: Breeding ecology of tits using artificial nest boxes between 2009 and 2010 at a deciduous forest, Ansung Campus, Chung-Ang University, South Korea

	2009			2010		
Species	Clutch size	Incubation period	Fledgling period	Clutch size	Incubation period	Fledgling period
P. palustris	10.50±0.71	19.00±3.32	17.43±0.79	10.00±0.00	21.50±3.03	22.11±0.78
P. major	9.50±1.64	18.61±3.27	15.71±2.09	6.33±0.58	21.46±2.99	24.00±1.55
P. varius	8.00±0.00	18.50±2.45	-	8.00±0.00	-	-

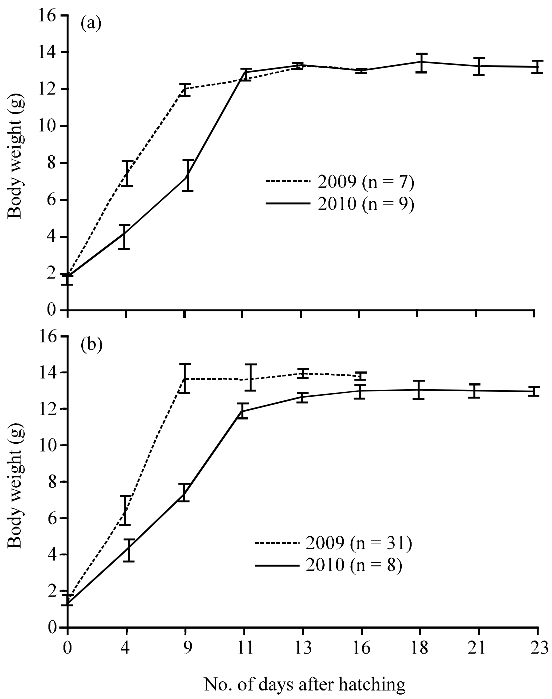

Fig. 3: Changes in body weight (g, mean±SD) of a) marsh tit *P. palustris* juveniles and b) great tit *P. major* juveniles after hatching between 2009 and 2010 at a deciduous forest, Ansung Campus, Chung-Ang University, South Korea

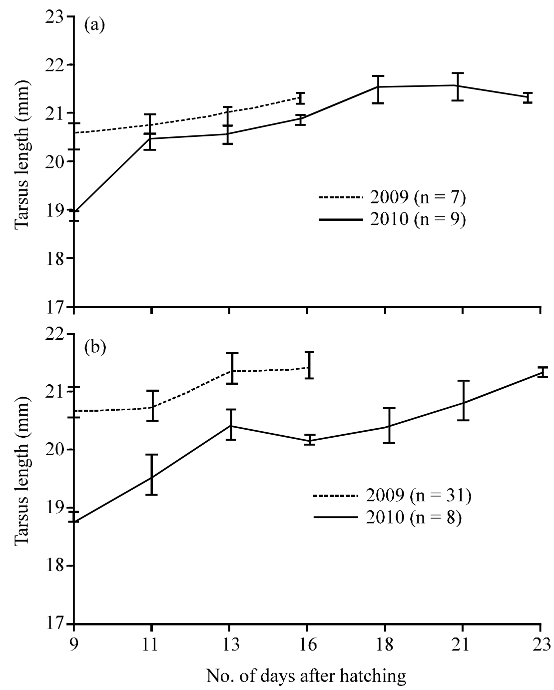

Fig. 4: Changes in tarsus length (mm, mean±SD) of a) marsh tit *P. palustris* juveniles and b) great tit *P. major* juveniles after hatching between 2009 and 2010 at a deciduous forest, Ansung Campus, Chung-Ang University, South Korea

March tit clutch size and incubation period were not different between 2009 and 2010. The fledgling period of marsh tits was significantly longer in 2010 than 2009 ($Z = -3.34$, $p<0.005$). In great tits, incubation ($Z = 2.51$, $p<0.05$) and fledgling periods ($Z = 3.45$, $p<0.005$) were significantly different between 2009 and 2010. Clutch sizes of great and varied tits were not different between 2009 and 2010 (Table 3).

The body weight of marsh tit chicks increased dramatically after hatching, reaching a plateau 9 and 11 days after hatching in 2009 and 2010. The rate of body weight increase was lower in the chicks of great tits than in marsh tits. However, this rate decreased after day 9 and 11 in 2009 and 2010, respectively. In addition, the rate of increase in body weight was slower in 2010 than in 2009 (marsh tit, $Z = -1.81$, $p<0.001$; great tit, $Z = -3.22$, $p<0.005$) (Fig. 3). Tarsus growth in great tits was significantly higher ($Z = -5.07$, $p<0.001$) in 2009 than 2010. However, there was no difference in the tarsus growth of marsh tits ($Z = 0.20$, $p = 0.84$). In addition, tarsus growth in just after the hatching was higher in 2009 than in 2010 (Fig. 4).

DISCUSSION

At low temperatures, egg production results in high energy expenditures for birds (Stevenson and Bryant, 2000). Moreover, egg production is costly with respect to future fitness benefits (Visser and Lessells, 2001). It is known that low temperatures increase the energy demands on birds (Selas *et al*., 2008). Thus, lower mean temperatures in March, 2010 may have influenced caterpillar hatching and leaf unfolding periods (Perrins, 1991).

Between March and June 2010, food resources may not have been sufficient due to higher humidity caused by higher precipitation (Visser *et al*., 1998; Radford *et al*., 2001). Therefore, rates of body weight and tarsus length increase were lower in 2010 than 2009. Furthermore, in bad atmospheric conditions such as low temperature, precipitation and periods of incubation and fledgling may have increased due to a decrease in the number of parental visits to the nest (Andrew *et al*., 2001).

There was a difference in the preferred diameter of entrance of the artificial nest boxes due to difference in bird body size (Rhim *et al*., 2011). Indeed, differences in body size and mass can influence interspecific social dominance (Jablonski and Lee, 1999). Thus, the differences in preferences for nest boxes by entrance diameter may have been related to interspecific social dominance.

Yearly variation in temperature may delay or accelerate the breeding phenology of birds. Specially, the costs and benefits of delaying or advancing hatching dates can differ significantly. A delay hatching dates could allow for larger clutch sizes however an increase in incubation period may increase the likelihood nest predation (Bosque and Bosque, 1995; Cresswell and McCleery, 2003; Bauer *et al*., 2010).

CONCLUSION

There can be large differences in vegetation or microclimate among study areas that affect food resource peak dates, leading to difference in the breeding ecology of tits (Visser *et al*., 2003; Shi *et al*., 2006). Therefore, long-term ecological research is needed to understand the relationship between atmospheric conditions and the breeding ecology of tits in temperate forests.

REFERENCES

Aslan, A. and M. Yavuz, 2010. Clutch and egg size variation and productivity of the House Sparrow (*Passer domesticus*): Effects of temperature, rainfall and humidity. Turk. J. Zool., 34: 255-266.

Bauer, Z., M. Trnka, J. Bauerova, M. Mozny, P. Stepanek, L. Bartosova and Z. Zalud, 2010. Changing climate and the phonological response of great tit and collared flycatcher populations in floodplain forest ecosystems in Central Europe. Int. J. Biometeorol., 54: 99-111.

Bosque, C. and M.T. Bosque, 1995. Nest predation as a selective factor in the evolution of developmental rates in altricial birds. Am. Nat., 145: 234-260.

Cody, M., 1985. Habitat Selection in Birds. Academic Press, San Diego, USA.

Cresswell, W. and R. McCleery, 2003. How great tits maintain synchronization of their hatch date with food supply in response to long-term variability in temperature. J. Anim. Ecol., 72: 356-366.

Crick, H.Q.P., 2004. The impact of climate change on birds. Ibis, 146: 48-56.

Eguchi, K., 1980. The feeding ecology of the nestling great tit, *Parus major major*, in the temperate ever-green broadleaved forest II. With reference to breeding ecology. Res. Popul. Ecol., 22: 284-300.

Jablonski, P.G. and S.D. Lee, 1999. Foraging niche differences between species are correlated with body-size differences in mixed-species flocks near Seoul, Korea. Ornis Fennica, 76: 17-23.

LG Evergreen Foundation, 2004. Study on habitat of wild bird and breeding ecology using artificial nest boxes. LG Evergreen Foundation, Seoul, Korea.

Laaksonen, T., M. Ahola, T. Eeva, R.A. Vaisanen and E. Lehikoinen, 2006. Climate change, migratory connctivity and changes in laying date and clutch size of the pied flycatcher. Oikos, 114: 277-290.

Lack, D., 1968. Ecological Adaptations for Breeding in Birds. Methuen, London.

Lack, D., 1971. Ecological Isolation in Birds. 1st Edn., Blackwell Scientific Publications, Oxford, ISBN: 9780674224421.

Lee, W.S., T.H. Koo and J.Y. Park, 2000. A Field Guide to the Birds of Korea. LG Evergreen Foundation, Seoul, Korea, ISBN: 9788995141519, Pages: 328.

Naef-Daenzer, B. and L.F. Keller, 1999. The foraging performance of great and blue tits (*Parus major* and *P. caeruleus*) in relation to caterpillar development and its consequences for nestling growth and fledging weight. J. Anim. Ecol., 68: 708-718.

Perrins, C.M., 1991. Tits and their caterpillar food supply. Ibis, 133: 49-54.

Radford, A.N., R.H. McCleery, R.J.W. Woodburn and M.D. Morecroft, 2001. Activity patterns of parent great tits *Parus major* feeding their young during rainfall. Bird Study, 48: 214-220.

Rhim, S.J. and J.Y. Lee, 2005. Differences in artificial nest boxes use of tits between deciduous and coniferous forests. J. Kor. For. Soc., 94: 338-341.

Rhim, S.J., S.H. Son and K.J. Kim, 2011. Breeding ecology of tits *Parus* sp. using artificial nest boxes in a deciduous forest. J. Kor. For. Soc., 100: 397-401.

Rhim, S.J., S.H. Son, M.J. Kim and J.H. Kang, 2008. Use of artificial nest boxes of tits in coniferous and deciduous forests. J. Kor. For. Soc., 97: 83-87.

Sanz, J.J. and M. Tinbergen, 1999. Energy expenditure, nestling age and brood size: An experimental study of parental behavior in the great tit *Parus major*. Behav. Ecol., 10: 598-606.

Selas, V., R. Steen, S. Kobro, T. Lislevand and I. Stenberg, 2008. Direct and indirect weather impacts on spring populations of lesser spotted woodpecker (*Dendrocopos minor*) in Norway. Scand. J. Forest Res., 23: 148-153.

Shi, J.B., D.Q. Li and W.F. Xiao, 2006. A review of impacts of climate change on birds: Implications of long-term studies. Zool. Res., 27: 637-646.

Son, S.H., 2010. Influences of temperature and humidity on breeding ecology of tits *Parus* sp. using artificial nest boxes in deciduous and coniferous forests. MS Thesis, Chung-Ang University, Seoul, Korea.

Son, S.H., K.J. Kim, H.S. Hwang and S.J. Rhim, 2012. Influences of temperature and humidity on breeding ecology of tits *Parus* sp. used artificial nest boxes in a coniferous forest. Kor. J. Ornithol., 19: 65-72.

Stevenson, I.R. and D.M. Bryant, 2000. Climate change and constraints on breeding. Nature, 406: 366-367.

Van Noordwijk, A.J., R.H. McCleery and C.M. Perrins, 1995. Selection for the timing of great tit breeding in relation to caterpillar growth and temperature. J. Anim. Ecol., 64: 451-458.

Visser, M.E. and C.M. Lessells, 2001. The costs of egg production and incubation in the great tits (*Parus major*). Proc. R. Soc. Lond. B, 268: 1271-1277.

Visser, M.E., A.J. van Noordwijk, J.M. Tinbergen and C.M. Lessells, 1998. Warmer springs lead to mistimed reproduction in great tit (*Parus major*). Proc. R. Soc., 265: 1867-1870.

Visser, M.E., F. Adriaensen, J.H. van Balen, J. Blondel and A.A. Dhondt *et al*., 2003. Variable responses to large-scale climate change in European *Parus* populations. Proc. Royal Soc. B Biol. Sci., 270: 367-372.