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Is there a relationship between fledge age and nest temperature in Western Bluebirds (*Sialia mexicana*)?

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Abstract

Extensive research has been done on temperature during bird incubation periods, but little has been done during nestling development, and to our knowledge, no studies have been done on Western Bluebird (*Sialia mexicana*) nestling development. In this study, dataloggers were used to monitor nest temperatures during the nestling development phase of Western Bluebirds to determine if there was a relationship between fledge age and temperature. The study was conducted in an existing nestbox network at Los Alamos National Laboratory and the surrounding area in north-central New Mexico. Based on the age of the nestlings at fledging, the nestboxes ($n=65$) were split into three groups: early (16 and 17 days old, $n=13$), average (fledged at or between 18 and 20 days old, $n=32$), and late (21 days or older, $n=20$). The temperatures of the early and average ($n=45$) groups were not significantly different ($p=0.32$, $W=3831000$). There was a significant difference in the temperatures between the early and late groups ($p=0.000$, $W=2965600$). The early and average groups were then combined, tested against the late group, and were found to be significantly different ($p=0.000$, $W=11315000$). Analysis showed a difference within the first seven days post-hatch of 1.42°C between the early/average and late groupings. The results suggest that warmer nest temperatures during the nestling stage may influence the fledge date and may lead to faster fledging. There may be numerous explanations for this, such as a correlation with nestling development, and higher temperatures may allow for faster development. Brood size was non-significant and was not factored into the analysis. Future work should be directed in this area.

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1.0 Introduction

Birds' internal core temperatures are higher than humans, averaging 40°C (Gill 2007). Based on this knowledge, the temperature in an active avian nestbox located in a high elevation, forested habitat, such as the Pajarito Plateau in northern New Mexico, should be higher than the outside temperature because ambient temperature does not normally reach higher than 40°C.

Most studies looking at temperature data on avian species focus on incubation and how these fluctuations, including parental incubation bouts, affect the fitness of the birds (Ardia, Pérez, and Clotfelter 2010; Berntsen and Bech 2016; Nord and Nilsson 2011; Pérez et al. 2008). Other literature focuses on thermoregulation of nestlings, but not how the microclimate of the nest affects nestling fledging age or nestling development. The literature on temperature observations during the nestling period has been neglected in the case of fledge age and nestlings' fitness. The studies that have been done manipulate various factors of a nest rather than observe and quantify the outcomes (Chaplin, Cervenka, and Mickelson 2002; Dawson, Lawrie, and O'Brien 2005).

Temperature dataloggers have been used to help determine nest failures in Leach's Storm-petrels (*Ceanodroma leucorhoa*) (Zangmeister et al. 2009) to determine incubation temperatures of Australian Gannets (*Morus serrator*) and Piping Plovers (*Charadrius melodus*) (Evans 1995; Schneider and McWilliams 2007), and to measure incubation rates (Ardia et al. 2006; Schneider and McWilliams 2007; Weidinger 2006) on a number of avian species. Dataloggers collect temperature at set and timed intervals, allowing researchers to observe temperatures at each individual nest throughout the day (Evans 1995; Schneider and McWilliams 2007).

The focus of this study is to monitor nest temperatures during the nestling development phase of Western Bluebirds to determine if there is a relationship between fledge age and temperature by collecting nest temperatures. Western Bluebirds (*Sialia mexicana*) average five eggs per clutch, with an incubation period averaging two weeks, and the fledging of the nestlings occurring between 16 and 22 days (Guinan, Gowaty, and Eltzroth 2000). Los Alamos National Laboratory has over 500 passerine nestboxes set up around Los Alamos County, creating the Avian Nestbox Network that has been monitored since 1997 (Fair 2001).

2.0 Methods

Field Methods

Data were collected from the Avian Nestbox Network on the Pajarito Plateau in northern New Mexico (Figure 1). The first step in determining the fledge age of a nest is to ensure the hatch date is known. This was accomplished by checking nests every two weeks (to give an approximation of incubation stage), followed by supplemental checks once a nest hatched. Visual observations from technicians at nest checks provide an age estimate. Temperature data collected from dataloggers are used to ensure the age is correct.

Western Bluebirds are the most abundant secondary-cavity nesting bird present within the Avian Nestbox Network project area. For this study it was also important to take into account the rate at which the dataloggers would collect data in order to determine the best use of resources. Maxim Integrated's Thermochron iButton® (Model: DS1921G) temperature datalogger was used for temperature collection. The rate was determined by taking several factors into account, such as additional stress to the nest from repeated visits and introduction of possible bias to the data. The most efficient time intervals to collect data were determined to be approximately every 25 minutes. Using this interval allows for the least disturbance to the nest and allowed the dataloggers to be in the nest cavity for approximately 35 days before being removed or replaced.

An ambient (control) datalogger is affixed to the bottom of each nestbox to assess temperature differences of the various locations and elevations. Dataloggers were only placed in nestboxes with eggs present. Each datalogger was set to record time on a 24-hour clock, taking temperature readings in degrees Celsius. Dataloggers are tied to a string connected to a key ring to keep them secure in the boxes, and reduce the likelihood of birds removing them (Figure 2). The dataloggers are placed underneath the nest, near the center of the box. Another option would have been to place the datalogger directly underneath the nest cup, by pulling apart a portion of the nest (Weidinger 2006); however, this method was not used because of the structure of the nest and the likelihood of destroying the nest. The control datalogger was secured with a pushpin underneath the box.

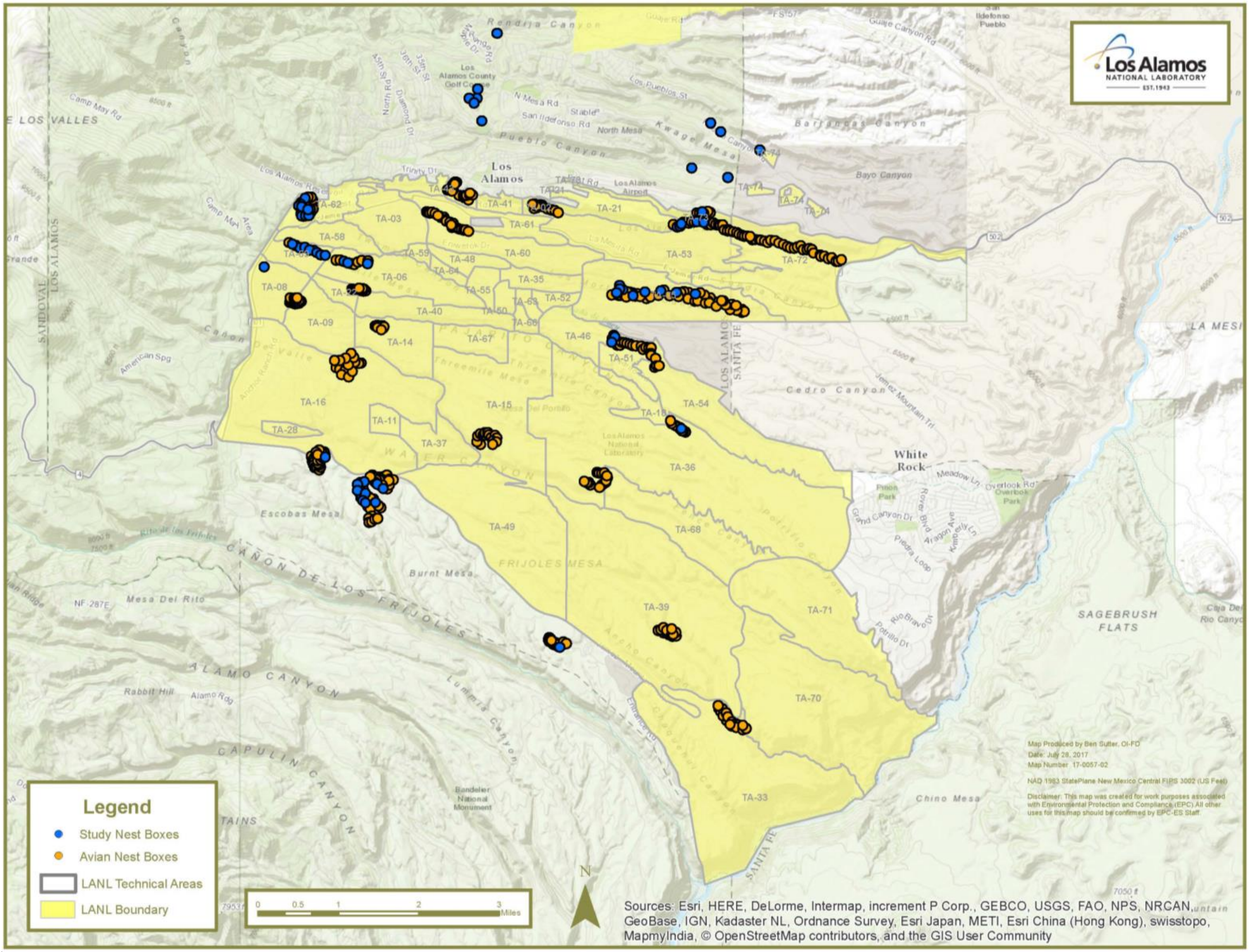

Figure 1 The Avian Nestbox Network: A map of Los Alamos County and the different nestbox locations. The blue dots represent the nestboxes with dataloggers in place over the study period.

Figure 2 Attachment method to secure ibuttons® to reduce the likelihood of adults discarding the ibuttons®.

The time and date are recorded when the dataloggers are placed at each box, along with the box number and number of eggs. Nestlings were banded with a standard United States Fish and Wildlife Service band at day 10 or greater. Once it is observed the fledglings have left the nest, the dataloggers are removed and the date and time of removal is recorded before deactivating the dataloggers. Other data are taken at nest checks including 1) date and time, 2) any action done at the box (i.e., banded nestlings or collected addled eggs, and 3) number of eggs and/or nestlings at each visit.

Data Analysis Methods

The temperature data recovered from the dataloggers are saved in a text file, before being moved to a spreadsheet. Rprogramming and RStudio were used for statistical analysis (R. C. Team 2013; Rs. Team 2015). Temperature data from 0300 and 0600 hours is used to remove any outside temperature influences on the nest temperature and control. The average fledge age of nestlings in the data is 19 days old. The data are split into three groups for analysis; early (16 to 17 days old at fledging, n=13), average (18 to

20 days old at fledging, n= 32), and late (21 days or older at fledging, n=20). Other analyses ran the data by brood size (BS) to compare with Chaplin et al., (2002) findings (BS of 2, n=8, BS of 3, n=17, BS of 4, n=11, BS of 5, n=26, BS of 6, n=2). Data were not normally distributed; therefore, a Wilcoxon nonparametric t-test was run to determine significances dependently (i.e., group together).

3.0 Results and Discussion

Data was collected from 65 nestboxes at different sites in Los Alamos County between May and July, 2015 to 2017. Brood size (BS) was non-significant and was therefore not factored into the rest of the analysis (Table 1). Field observations and recorded temperature fluctuations during the nesting period were used in order to determine hatch and fledge dates, and to remove unwanted temperature data. Temperatures based on brood size were found to be significant to one another in seven out of ten cases. (Table 2).

Table 1 Brood Means and Sizes in Relation to Groups

	p-value
Early (μ=3.9) to Average (μ=3.8)	0.8862
Average (μ=3.8) to Late (μ=4.2)	0.2479
Early (μ=3.9) to Late (μ=4.2)	0.3266

Note: Brood size in relation to groups is non-significantly different.

Table 2 Brood Size in Relation to Temperature

	p-value
BS 2 (n=8) to BS 3 (n=17)	**0.000**
BS 2 to BS 4 (n= 10)	**0.000**
BS 2 to BS 5 (n=24)	**0.000**
BS 2 to BS 6 (n=2)	0.949
BS 3 to BS 4	0.066
BS 3 to BS 5	0.343
BS 3 to BS 6	**0.000**
BS 4 to BS 5	**0.026**
BS 4 to BS 6	**0.000**
BS 5 to BS 6	**0.000**

Note: Brood size temperatures (n=61) show most to be significant to one another.

When the nest temperature reached a similar temperature (within 1.5–2°C) to the ambient temperature, then it was considered an inactive nest and trailing data was discarded. Hatch date was determined based on the recorded dates of field observations of the nestlings and approximation of age to cross-reference with post processing of datalogger information. Figure 3 shows the temperature difference between a control and a nest of a single Western Bluebird nest. Using field observations and the temperature data, it is possible to determine different parts of the nesting period (Figure 3; i.e., laying eggs, incubation, nestling age, fledge date).

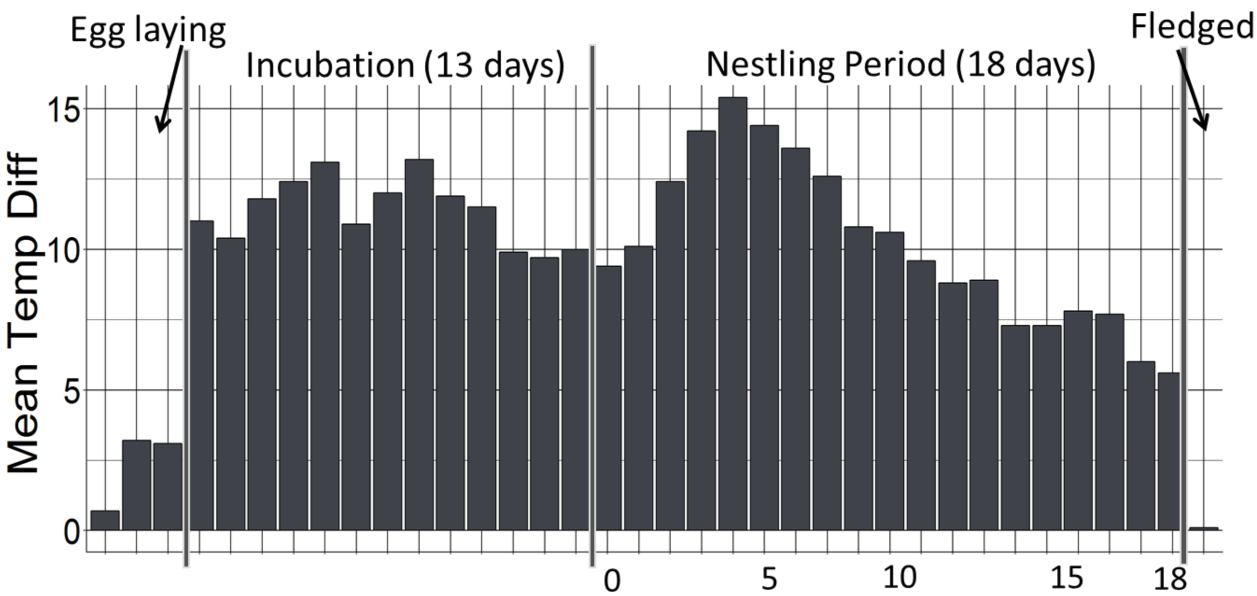

Figure 3 Temperature observations of singular nests show a similar pattern between individual nests.

The mean nest temperature by sampling period for all nests during the nestling period (Figure 4, n=65) shows an increase in temperature before tapering to a lower steady state. Brood size between groups were non-significant to one another and therefore were not used in the analysis.

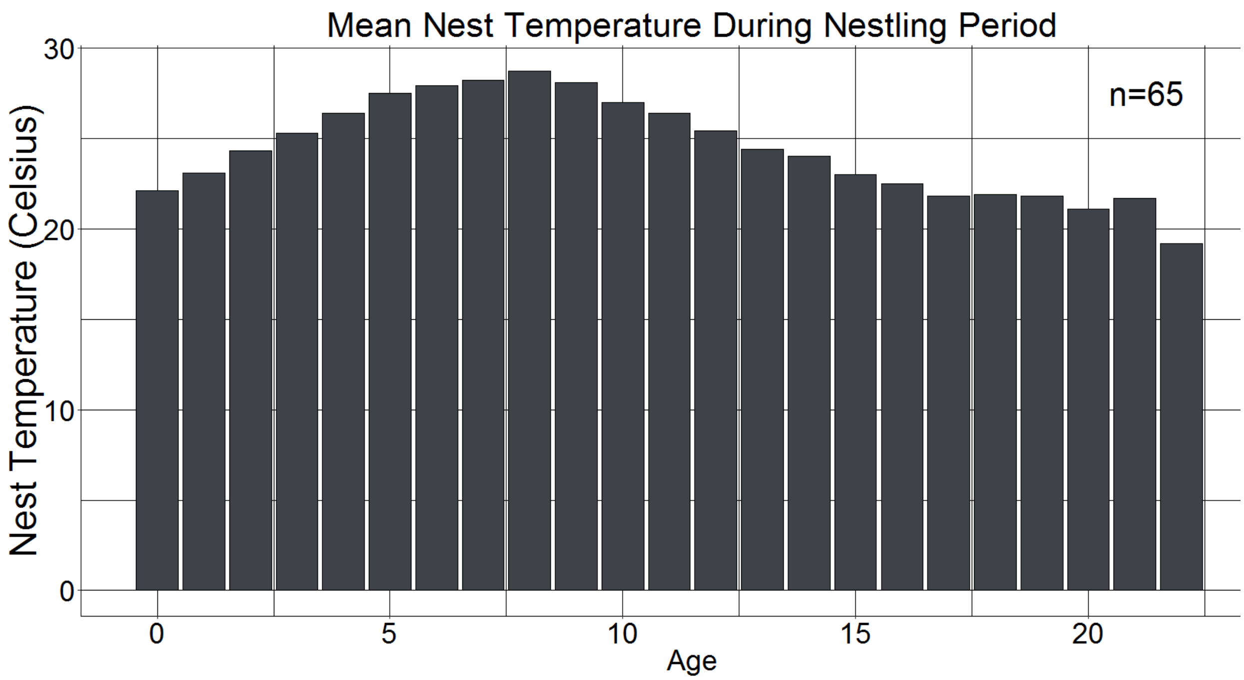

Figure 4 Mean nest temperature of all nests.

A Wilcoxon test was used to compare the groups with one another (Figures 5 and 6). The average and early groups (Figure 5) were not significantly different to one another ($p=0.32$, $W=3831000$). There is a significant difference in the temperatures between the early and late groups ($p<0.000$, $W= 11315000$). The early and average groups were combined and tested against the late group and were found to be significantly different (Figure 6) with a mean temperature difference of 0.86°C ($p<0.000$, $W=11315000$).

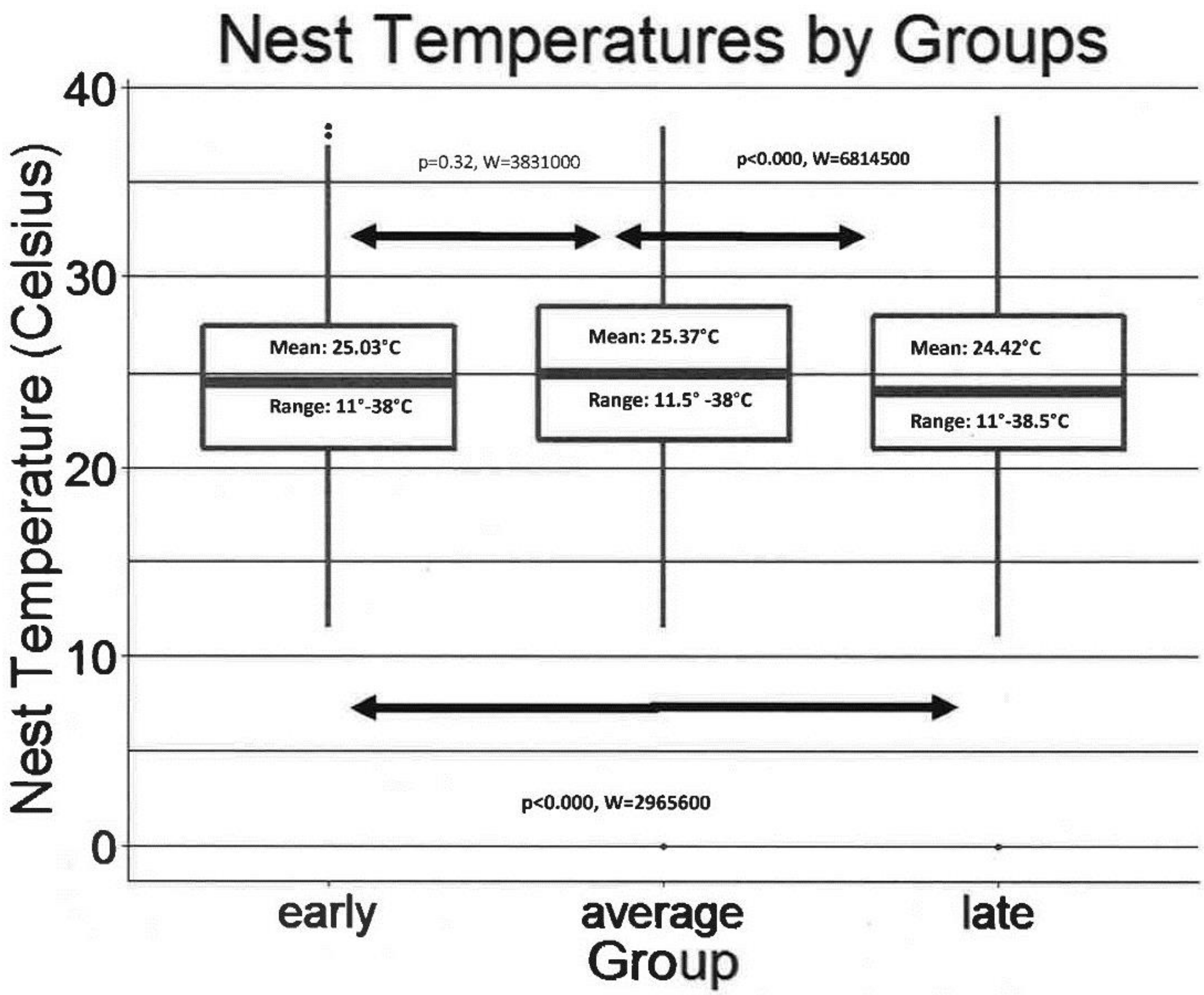

Figure 5 **Early and late, and average and late groups are significantly different.**

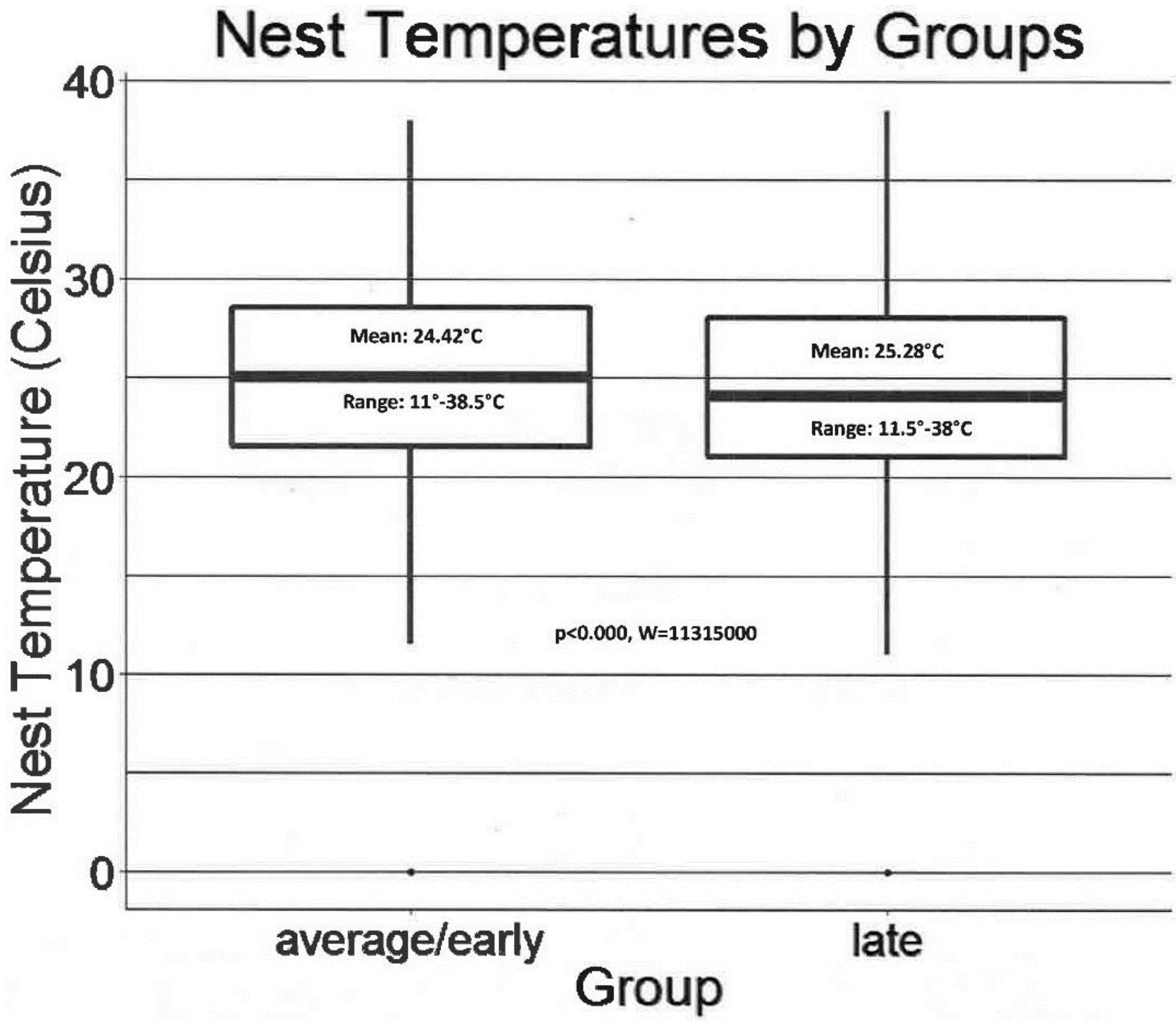

Figure 6 Grouped average/early and late group are significantly different.

For each group (i.e., average/early and late), temperature data were grouped by day and the mean was run for each (Figure 7). For the first week after hatching, there was a 0.6-2.1°C difference between each day, with a mean difference of 1.42°C.

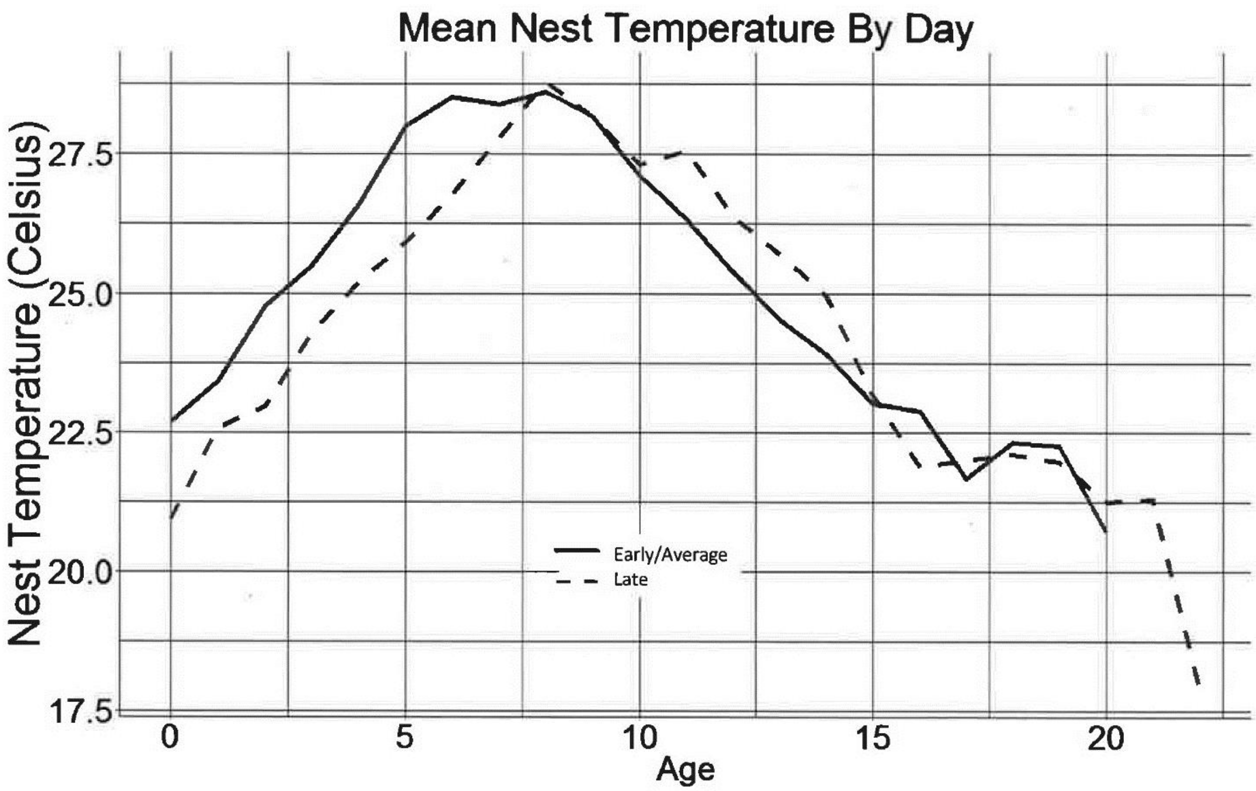

Figure 7. Mean nest temperatures by day.

Two different studies manipulated the nests of tree swallows (*Tachycineta bicolor*) and found that temperature and brood size can affect the outcome of a nest. Chaplin et al. (2002) manipulated the brood size of tree swallows and found larger broods of six had a higher nest temperature than broods of three. The nest temperature may be related to the thermoregulatory skills of the nestlings; however, the smaller brood had significantly higher masses. Dawson et al. (2005) artificially heated tree swallow nests and found while there was no significant difference in nest success or tarsus length, there was a significant difference in the ninth primary feather growth between the heated and controlled boxes. These two studies indicate that temperature may play a role during the nestling period, but more study is needed to determine the exact role temperature plays.

Results from this study show an average 0.86°C difference between the average/early and late group. The largest difference in temperature is seen in the first seven days after hatching.

The brood sizes of two and six were found to be the most non-significant to one another (p-value = 0.949). While seven out of the ten tests run on brood sizes in relation to temperature are significant, the sample size for each brood size is very different, and therefore should not be compared with Chaplin et al. (2002) findings until more data is added. Only 61 nests were used in the brood size analysis due to missing data.

The mean temperature by day for all nests show an increase in temperature up to day eight before falling; this may have to do with an increase in biomass before feather development allows for the nestlings to have better insulation. Because of the significant difference between the average/early group and the late group in the first seven days, food or hereditary thermoregulation skills may also be factors. This data helps understand how temperature plays a role after the incubation period, which is the main focus of most temperature research questions in avian species. For future work, in addition to temporal observations, physical data measurements of nestlings could be taken at each nest with a datalogger, or vice versa, to determine if nest temperature has an effect on nestling development.

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