Investigating Barn Owl Nest Box Size and Use of Shade Panels to Mitigate Extreme Temperatures (Abstract)

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ABSTRACT: American barn owls (*Tyto furcata*; hereafter barn owls) are commonly attracted to breed on California farms for Integrated Pest Management; however, nesting barn owls face threats from the accelerating frequency and severity of heatwaves. Previous research has shown that the upper limit of a barn owl's thermal neutral zone is 32°C (90°F) (Thouzeau et al. 1999). Negative effects of extreme temperatures on avian taxa include stunted nestling growth (Salaberria et al. 2014), delayed fledging (Cunningham et al. 2013), dehydration (Salaberria et al. 2014), hyperthermia (Thouzeau et al. 1999), and death (Hindmarch and Clegg 2024). We compared temperatures between two commonly used nest box designs to investigate heat mitigating attributes of size and shade panels. This study took place on a vineyard in the Central Valley of California, USA, with a Mediterranean climate where temperatures regularly rise above 38°C (100°F) in the summer (Table 1). The two box designs are freely available online. The smaller (hereafter, small) nest box's dimensions are 57.8 × 40.6 × 31.4 cm (22.75" × 16" × 12.375") with a volume of 11,443 cm^3 (4,505 in^3). The larger (hereafter, large) nest box's dimensions including the shades are 76.2 × 78.7 × 52.7 cm (30" × 31" × 20.75"), and without shades are 61 × 61 × 45.7 cm (24" × 24" × 18") with a volume of 26,334.7 cm^3 (10,368 in^3). We used Maxim Integrated iButtons (models: DS1921G, DS1923; Analog Devices, Inc., Wilmington, MA) to measure internal temperatures of the two nest box designs. Ambient temperature was extracted from an on-site weather station.

We used a Kruskal-Wallace and a pairwise Wilcoxon test to assess temperature differences between large box, small box, and ambient. We used a linear mixed-effects model using the nest boxes' ID as a random factor to compare internal daily maximum temperatures with an interaction between nest box design and ambient daily maximum temperatures. All analyses were performed using R Statistical Software (V4.2.3)(R Core Team 2023). We collected hourly temperature from four large nest boxes (n = 13,541) and four small nest boxes (n = 9,728) from April to October 2023. Small nest boxes were significantly hotter than large nest boxes and ambient temperature (smaller-larger $p < 0.001$; smaller-ambient $p < 0.001$). There was no statistical difference between larger nest boxes and ambient temperature (larger-ambient $p = 0.54$). The interaction of box design and ambient temperature significantly influenced internal nest box temperatures. For every 1°C (1.8°F) increase in ambient temperature, larger nest box temperature increased by 0.92°C (1.7°F), and smaller nest box temperature increased by 1.05°C (1.89°F). We compared two commonly used barn owl nest box designs and found the smaller nest box was 5°C (9°F) warmer than large nest boxes when ambient temperature nears the upper limit of a barn owl's thermal neutral zone of 32°C (90°F).

This pilot study demonstrated that larger nest boxes with shade panels may keep internal temperatures cooler compared to smaller nest boxes without sun protection (Table 2). Because we did not measure the temperatures in large nest boxes without shade panels or smaller nest boxes with shade panels, we cannot fully assess how nest box size, presence of shade panels, or the combination of both size and shade features influenced the nest box temperatures observed in this study. Further research is needed to identify if smaller nest boxes modified to include shade panels could adequately buffer nesting barn owls from extreme temperatures and heatwaves. This data could inform land managers on the trade-offs between retrofitting existing smaller nest boxes or allocating resources to upgrade to larger nest boxes with shade panels. To maximize the benefits that barn owls provide in Integrated Pest Management programs, nest box temperature in relation to climate should be considered.

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Table 1. Summary statistics of all hourly recorded temperatures (All Temperatures) and daily maximum temperatures (Maximum Daily Temperatures) recorded between April and October 2023 in different-sized barn owl nest box designs, and ambient temperature in the Central Valley of California.

All Temperatures (°C)			
	Mean	**SD**	**Range**
Small	23	9.5	3.5 - 48
Large	22	7.4	3.5 - 41
Ambient	23	7.5	4.1 - 42
Maximum Daily Temperatures (°C)			
	Mean	**SD**	**Range**
Small	35	6	32 - 48
Large	31	5.3	28 - 41
Ambient	30	5.4	27 - 42

Table 2. Results summary from a linear mixed-effects model used to compare internal nest box temperatures to different-sized nest box designs and ambient temperatures. Nest box ID was used as a random factor. Larger nest box design was used as a reference for the intercepts and slopes, respectively. Bolded coefficients represent significant findings ($p < 0.05$).

Parameter	Coefficient [95% CI]	SE	T-value
Intercept	**2.26 [0.83 , 3.69]**	0.73	3.108
Max ambient	**0.92 [0.89 , 0.95]**	0.02	61.098
Nest box design	1.90 [-0.11 , 3.90]	1.02	1.858
Max ambient × nest box design	**0.13 [0.08 , 0.17]**	0.02	5.948

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