Horodas Family Foundation for Conservation Research – Proposal

Project Title: Why do the effects of temperature on nestling growth and survival vary across land uses?
Applicant (WFCB PI Status): Daniel Karp
Participants (degree objective if student): Katherine Lauck (PhD student)
Total Request: $4922.99 **New /Continuing Funding Request (circle one)**

Background

The interactive effects of climate change and habitat conversion to agriculture constitute the primary threat to terrestrial wildlife (Travis 2003). Efforts to increase biodiversity in agricultural landscapes, such as planting polycultures, may allow more species to thrive in human-dominated landscapes (Kremen and Merenlender 2018). However, as climate change progresses, human-dominated landscapes may expose birds to new temperature extremes because converting forested land to agriculture removes trees that insulate the understory from ambient temperature (Suggitt et al. 2011, De Frenne et al. 2019). In bird species with altricial young, nestlings are ectothermic, so both low and high temperatures divert energy from growth to thermoregulation (Dunn 1979). The lethal effects of cold are well-documented (Shipley et al. 2020). But in the future, climate change will drive temperature increases globally and exacerbate the intensity of short-term temperature spikes. Especially in hot ecosystems, climate change-driven temperature spikes often induce nest failure and drive population collapse (Socolar et al. 2017). For example, in the Putah Creek ecosystem near Davis, CA, warm temperatures during nesting are associated with lower nestling growth (and survival in some species) (Riggio *et al.* in prep). Furthermore, our preliminary results from an analysis of Cornell University's NestWatch database (N= 152,863 nesting attempts across 58 species) show that, across North America, temperature spikes lower nesting success in agriculture and urban environments. However, nesting success remains stable in grassland and increases in forested areas following temperature spikes.

WFCB undergraduate Katia Goldberg has proposed a project to the Swift Endowment seeking to compare nest temperatures between multiple land uses to determine whether closed canopies buffer nests from temperature spikes. For this project, I will investigate the two main mechanisms that could underlie the effects of heat waves: direct thermoregulation challenge for nestlings and food availability. Nestlings can survive heat waves by using more energy to thermoregulate, but this may increase stress, decrease growth, and lead to lower survival (Wingfield et al. 2017). Furthermore, heat waves may reduce food provisioning to nestlings, either by forcing adults to spend more energy thermoregulating or by reducing prey availability. For example, warming temperatures are driving lepidopteran declines across the U.S. (a key resource for young birds; Forister et al. 2021). Here, I propose to investigate the relative contributions of thermoregulation challenge and food provisioning to nestling growth under temperature spikes across four land uses: natural open canopy (grassland), natural closed canopy (riparian forest), agricultural open canopy (row crop), and agricultural closed canopy (orchard).

Questions

Question 1. How do ambient temperature and land use affect food provisioning for nestlings?
Hypothesis 1. Temperature spikes will be more frequent and more severe in grassland and row crop (*i.e.*, open lands), decreasing provisioning rates. Parents may decrease foraging time to meet thermoregulatory demands or lower insect availability may increase search effort.
*Question 2***.** How do next box temperature and land use affect nestling stress physiology?
Hypothesis 2. Temperature spikes will be more frequent and more severe in row crop and

grassland systems, which will increase nestling stress (*i.e.*, cortisol levels). High temperatures may cause hyperthermia, which can elevate cortisol in nestlings (Wingfield et al. 2017).
Question 3. How does land use affect the relative importance of physiological effects of heat (Q2) versus food-mediated effects (Q1) on the growth and fledging success of nestlings?
Hypothesis 3. In open land uses (i.e., grassland and row crop), the direct effects of heat on nestlings will dominate. Hyperthermia will drive cellular damage, forcing nestlings to expend more energy on maintenance, lowering their growth (Wingfield et al. 2017). However, because hyperthermia may also cause adults to decrease provisioning during temperature spikes, food-mediated effects may also be important. In agricultural lands, low resource (*i.e.*, insect) availability will cause food-mediated effects to dominate.

Methods

To address these questions, I will monitor Tree Swallow and Western Bluebird nest boxes in four land use treatments: row crops, orchards, grasslands, and high canopy cover riparian forests. I will partner with the Museum of Wildlife and Fish Biology (MWFB) to access their 'Putah Creek Nest Box Highway,' a network of 169 nest boxes along Putah Creek. However, the Nest Box Highway does not include nest boxes in row crop agriculture or enough boxes in orchard or grassland sites. Thus, I am working to secure landowner permissions to expand the network. In early April, we will begin monitoring 36 boxes (N= 3 nests/site * 3 sites/land use * 4 land uses). After chicks fledge, we will move on to new nests. We expect to complete 3 rounds of sampling for a total of 108 nests monitored in 2021.

I propose to monitor the same nest boxes that Katia Goldberg (see above) will use to explore temperature differentials between land-use types. She will place HOBO loggers inside boxes to measure nest temperature following egg-laying. To quantify parental food provisioning rates, I will use Raspberry Pi-based motion-activated cameras (Phillips et al. in review) that will record 30 seconds before and after motion activation. I will use generalized linear mixed models (GLMMs) to compare the effect of temperature on provisioning rates across the four land use types (Question 1). Starting in March 2022, I will partner with Dr. Paulina Gonzalez to collect blood samples from nestlings and use ELISA assays to measure cortisol concentrations. Again, I will use GLMMs to compare effects of temperature on nestling cortisol concentrations among land uses (Question 2).

To address question 3, I will partner with the MWFB to monitor nestling growth and survival. Within their current nest box network, project scientist Hanika Cook and her team will record mass, tarsus length, bill length, and wing chord of nestlings twice during the nestling period and band them at the appropriate time. I will be trained to handle, measure, and band nestlings according to their protocol. I will then monitor the additional boxes placed in row crops, orchards, and grasslands. Again, I will use GLMMs to compare effects of provisioning rate and nestling cortisol concentration on nestling growth and survival rates among land uses.

Justification

The results of this project will provide crucial insight into the mechanisms by which climate change may affect the ability of birds to survive in human-dominated habitats. In doing so, it will also provide concrete avenues through which working landscapes could be modified to better accommodate cavity-nesting birds. If the direct effects of heat are more important than food-mediated effects, nest boxes could be modified to increase nesting success; for example, by adding white paint or solar shields to roofs, or by installing boxes in more shaded areas. In contrast, if food-mediated effects predominate, then maintaining patches of non-crop habitats in working landscapes to support food resources for birds (*i.e.*, insects) may be more effective.

Literature cited

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Budget

Item	Quantity	Price	Total	Grant
1. Transportation	1710	$0.56	$957.60	Selma Herr
2. Motion-activated video cameras	24	$100.00	$2,400.00	Selma Herr
3. ELISAs (est. per sample)	432	$10.00	$4,320.00	Horodas Family Foundation
4. Nest boxes	70	$30.00	$2,100.00	Donated by MWFB volunteer
5. Nest box poles	20	$16.70	$334.00	Horodas Family Foundation

6. Nest box poles	50	$16.70	$835.00	Requested from Swift Endowment
7. HOBO temp + humidity monitor	12	$170.00	$2,040.00	Already available in Karp Lab
8. HOBO temp monitors	80	$54.00	$4,320.00	Already available in Karp Lab
9. Mallet	1	$29.99	$29.99	Horodas Family Foundation
10. Gloves	2	$12.00	$24.00	Horodas Family Foundation
11. GPS	1	$215.00	$215.00	Horodas Family Foundation

TOTAL: Grand Total- $8280.59; Selma Herr- $3357.60; Horodas Family Foundation- $4922.99

Justification

1. Transportation: We will use Katherine Lauck's private vehicle to travel to field sites for this project. Estimated average 30 mi/day * $0.56/mi * 3 round trips/week * 19 weeks of field work. We will use a private car to access field sites, and compensate the owner for mileage at the UCD rate. The amount requested will cover transportation for the Summer 2021 field season.

2. Cameras: As noted in the proposal, our intent is to monitor 36 active nests at once (4 land use types, 3 sites/land use, 3 boxes per site). To balance sufficient a sample size with the considerable effort needed for video post-processing, our plan is to monitor food provisioning from parents at 2 of the 3 boxes per site. Therefore, we request sufficient funds to acquire 24 cameras (i.e., 4 land-use types, 3 sites/land-use, 2 boxes per site). The cameras that we will use are based on a Raspberry Pi one-board computer - we plan to overcome the limitations of motion activation for birds, which typically move too quickly for capture by cameras that start recording at motion activation, by programming the camera to record constantly, predawn to dusk, but only save footage 30 seconds before and after a motion activation. The estimated cost per camera includes a Raspberry Pi board, a microSD card, a microUSB flash drive, a battery, a real-time clock, a motion sensor, a camera and case, a container, sealant, desiccant, velcro for attachment, and a fraction of one-item costs such as a stand-alone keyboard, microUSB extender, and a setup battery.

3. ELISAs: As noted in the proposal, we will quantify physiological stress by assaying blood cortisol using ELISAs. The cost of an ELISA kit is $270 and it contains sufficient reagents to quantify stress hormones for 35 samples (including necessary controls). Including field and lab consumables (i.e., gloves, pipette tips, Eppendorf tubes, capillary tubes, syringes for blood

extraction, etc.), we estimate the per-sample price for quantifying stress hormones to be ~$10/sample (i.e., $7.70/sample for ELISA kits and $2.30/sample for consumables). We plan to monitor 108 nests (N= 4 land-use types, 3 sites/land-use, 3 nests/site, 3 sampling rounds) and estimate an average of 4 chicks per nest. Thus, in total, we plan to sample 432 individuals.

4. Nest boxes: As noted in the proposal, we need to install 70 new nest boxes (7 sites with 10 boxes each - three row crop sites, three orchard sites, and one grassland site), to complete the study design of three replicates of each of four land use types. These new nest boxes are being donated to the project by the MWFB.

5 & 6. Nest box poles: As noted in the proposal, we need to install 70 new nest boxes (7 sites with 10 boxes each - three row crop sites, three orchard sites, and one grassland site), to complete our study design of three replicates of each of four land use types. 50 of the poles were requested as part of Katia Goldberg's Swift Endowment Fund proposal. We are requesting funds to acquire the other 20 poles.

7. HOBO temp/humidity loggers: Irrigation in agriculture may interact with temperature to mitigate or exacerbate its effect. 12 humidity loggers allow us to place one at each site to control for these possible effects (3 sites of each land use type * 4 land use types). Loggers are already available in the Karp lab.

8. HOBO temp loggers: As noted in the proposal, Katia Goldberg will place temperature loggers at 36 nests across our study sites (3 nests/site * 3 sites/land use type * 4 land use types). At each nest, she will place two temperature loggers, one inside and one outside. Loggers are already available in the Karp lab.

9. Mallet: When installing nest boxes, we need to install rebar into hard ground; thus, we need a hefty mallet that will not spread the top of the rebar.

10. Gloves: As noted in the proposal, we need to install 70 new nest boxes. Gloves will protect our hands when handling sharp metal.

11. GPS: As noted in the proposal, we will place 70 new nest boxes. A GPS unit will ensure that an accurate location for each is assigned and when monitoring, we will accurately identify each nest box.

Signed funding agreement

All funds awarded will be expended by the end of the academic year. If funding is awarded, a thank you letter to the Horodas Family Foundation (submitted to the WFCB Chair) explaining the project's results and value, and a project summary, including accounting of funds expended, will be placed in WFCB files.

Daniel Karp Date: 3.10.21