Title: Quantifying Effects of Elevation and Urbanization on Chickadee Nestling Development along the Colorado Front Range

Objective: This project seeks to explore the effects of urbanization and elevation on nestling development in black-capped and mountain chickadees along an urban-rural elevation gradient.
Significance: Understanding variation in nestling development between and within chickadee species in Colorado will provide insight into the role that urban disturbances play on chickadee survival and persistence in urban areas and will help us understand how these species are affected by increasing anthropogenic interference. This study might also help in understanding the influence of elevation on life history as these species 'ranges may shift in response to continued climate change.

Introduction: Urbanization is rapidly altering natural environments around the world and species that occupy these areas must adapt to their surroundings or leave. As urban areas expand, the ability for species to quickly adjust is tested, which can have significant impacts on aspects of life history such as breeding, reproductive success, and species interactions. The effects of urbanization on physiology have been examined, but results remain inconsistent and appear to be dependent on how adapted the species is to urban life (Bailly 2015; Marini 2017; Muller 2020; Meillére 2017; Satgé 2019). Also, the extent to which nestling development is impacted by urbanization is still understudied (McDonald 2020), despite the developmental period proving to be the most crucial time in the vertebrate life cycle, setting the tone for adult performance and reproduction later in life. I seek to explore how chickadee nesting success is affected by urbanization along an elevation gradient and to characterize how this differs within and between two chickadee species that co-occur along the Colorado Front Range. The pace-of-life syndrome (POLS) hypothesis is a life history strategy that suggests that closely related speciesshould differ in various physiological, behavioral, and morphological traits that are associated with variation in their life history (Réale 2010). Also described as the fast-slow life-history continuum, species on the fast-end of the continuum tend to experience high reproductive rates, low parental investment, and shorter life spans (Boyle 2016). Species who are more adapted to living in urban areas will most likely exhibit fast-end traits (Boyle 2016; Marini 2017). The continuum shifts to slower life-history strategies as elevation increases and anthropogenic disturbance decreases, where high elevation populations experience colder temperatures, have shorter breeding seasons, and decreased food availability (Boyle 2016). When applying this life history theory to the chickadee study system, I hypothesize that Black-capped chickadees should fall closer to the fast-end, urban-adapted species, whereas Mountain chickadees should fall near the slow-end of the continuum

Study System: Black-capped (BC) and Mountain (MC) chickadees are small, nonmigratory passerines that occupy a range of habitats along elevational and urbanization gradients. BC can be found in deciduous forests and mixed tree forests, open spaces, and disturbed habitats near urban areas at lower elevations, while MC prefer the high elevation coniferous forests of western North America. Both species are commonly found at backyard feeders across much of North America, and as cavity nesters, readily take to nest boxes. BC and MC experience ecological segregation based on their geographic range, but BC are DFO Research, Education, and Conservation Grant 2022 Larrieu, Mia more dominant over MC in areas of sympatry (Grava 2012). BC and MC are known to hybridize in areas of close proximity, but the long-term success of hybrid chicks has not been characterized (Grava 2012, prev. data). The main aim of this study is to characterize nestling development of both chickadee species across urban disturbance gradients at multiple elevations to identify differences in overall nesting success between and within species.

Methods
Location: I will monitor breeding and nesting of both BC and MC using an extensive network of ~400

established nest boxes run by the Boulder Chickadee Study at the University of Colorado Boulder. These nest boxes are installed along an elevation gradient that spans from the urban setting of Boulder, CO up to the rural setting of CU Boulder's Mountain Research Station near Nederland, CO. Nest boxes are located throughout the city of Boulder, CU Boulder's main campus, and end at the Mountain Research Station, with boxes located at intermediate elevation and disturbance on Lower and Upper Sugarloaf Mountain. Sampling will take place for one breeding season (April to July 2022).

a) Observational Breeding Surveys: I will monitor BC and MC activity at nest boxes to collect observational data of breeding behavior for adult chickadees during incubation. Incubation periods and feeding frequency of BC and MC parents will be recorded at each nest box. Since elevation and urbanization are often correlated and difficult to disentangle from each other, I will also define degrees of urbanization by quantifying disturbance around the nest boxes and defining a measure for urbanization index at each nest (LaZerte 2017). I will measure the proximity of the nest box to any nearby roads, housing, or other nest boxes and quantify the presence of non-native tree species and impervious surface area. b) Nestling Surveys: Using previous breeding data from 2019-2021, we know that BC typically start nesting 1-2 weeks before MC and clutch initiation is delayed by 2 weeks between each of our main sites as elevation increases. After hatching, nestlings will be measured every other day until they fledge. Body size, weight at fledging, and wing condition are reliable proxies for evaluating developmental growth in nestlings (Biard 2017). Morphological measurements including mass, wing chord, tail length, and tarsal length will be taken at each nest visit for each chick. At day 12, the chicks will be banded, and I will collect blood and feather samples to quantify evidence of stress by looking at cortisol, an important hormone involved in regulating stress, via growth bars from feather samples (Bortolotti 2008). The Taylor Lab at the University of Colorado Boulder possesses all the necessary permits required for capturing, banding, and collecting blood and feather samples from chickadees (Federal Bird Banding and Marking Permit 24169; Scientific Collection License -- Colorado Parks and Wildlife 22TRb2442; IACUC Protocol 2683) c) Nest Box Camera Surveys: Cameras placed in nests can help to address common research questions posed by scientists including topics involving nestling behavior, parental care, predator identification, and even capture footage of rare events and behaviors one would not typically have the chance to witness during regular nest monitoring visits (Cox, et al. 2012, Williams & DeLeon, 2020). 30 nest box cameras (10 cameras distributed across the three main elevation categories: low, intermediate, high) will be placed at nest boxes that have consistently shown nesting activity during the previous three years in order capture nestling behavior within the nest for both BC and MC along the elevation gradient. Four trail cameras will be placed at nests that experienced previous predation events during monitoring. I will use camera footage to quantify parent visits and nestling feeding rates, characterize milestones of nestling development (open eyes, appearance of feathers, alertness, movements), monitor nestling behavior, and identify predation events.

Project Timeline: Field work will begin Spring 2022 and continue into the Summer 2022 to collect nestling data (including setting up cameras at a sample of nest boxes to capture behavior of parents and nestlings within the nest). Fall 2022 will consist of analyzing all nestling data and nest camera footage and begin writing up my preliminary results. The study will be conducted by me under the guidance of my direct mentor and graduate advisor Dr. Scott Taylor, as part of the Boulder Chickadee Study at the University of Colorado Boulder. This research is part of a multi-year dissertation study of chickadee nesting ecology, behavior, and hybridization in Colorado