Urbanization alters molt dynamics in a common desert songbird

Central Arizona-Phoenix Long-Term Ecological Research CAP LTER

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Problem Statement

- Earth's terrestrial surface is being urbanized rapidly
- Knowledge of **how urbanization affects the physiology and behavior of animals** is vital for conserving historical functions of populations, communities, and ecosystems
- The urban environment introduces anthropogenic stressors such as **pollution, prolonged light exposure, and altered diet**
- In birds, most work has focused on urban modifications of:
  - Stress physiology. **Urban birds have upregulated HPA axis activity[1]**
  - Reproduction. **Urban birds generally breed earlier[2]**
  - Migration. **Urban populations sometimes do not migrate[3]**
- ***We do not know how urbanization affects the temporal dynamics of feather growth during molt***
- **Molt** is an energy-intensive life-history trait which functions to replace worn feathers. **Plumage** serves many functions such as **thermoregulation and display of sexual signals**

Hypotheses and Predictions

- **Hypothesis 1**: Urban and rural birds **begin molt at different times**
  - ***Prediction 1***: Given that **urban birds** are generally in poorer condition, we predicted they would **begin molting later**
- **Hypothesis 2:** Urban and rural birds **molt at different rates**
  - ***Prediction 2*: Urban birds** will molt at a **slower rate**

Methods

- We followed the molt progress of a common rural and urban desert songbird, the house finch (*Haemorhous mexicanus*)
- For **14 weeks** (June-October 2014), we visually estimated the **proportion of molting contour feathers** (i.e. crown, breast and rump; Figure 1) of **both males and females of all ages** at four sites along an urbanization gradient in Phoenix, AZ (Figure 2)

Figure 1. Pictures of molting feathers in the colorful body regions of house finches. The growing feathers have white sheaths at the base. Left: Partially molted crown feathers. Middle: Partially molted breast feathers. Right: Partially molted rump feathers.

- Each study site was visited **every two weeks**, and we aimed to capture 20-25 birds per visit (N = 627) with baited barrel traps. We added "individual" in our models as a random factor to control for recaptures

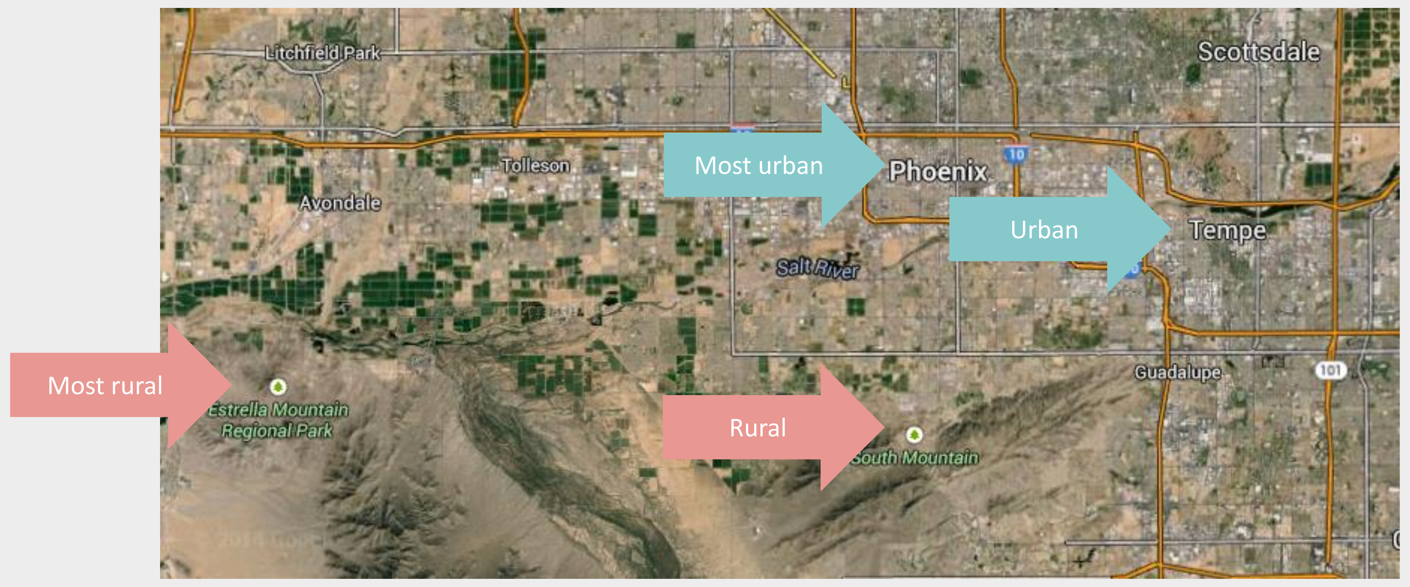
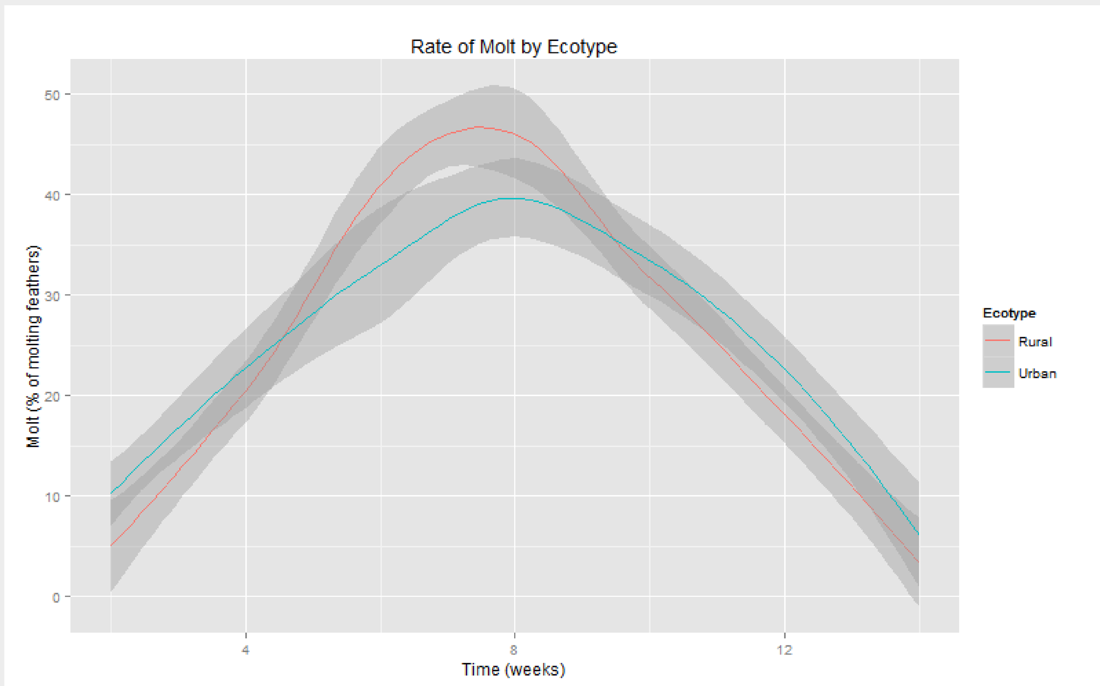


Figure 2. Geographical distribution of study sites. Based on previous studies of satellite images (Giraudeau et al. 2014), the sites in order from most to least urbanized are: Downtown Phoenix, Arizona State University - Tempe Campus, South Mountain Regional Park, and Estrella Mountain Regional Park.

Results



- Figure 3. Loess smoothers of molt progress by ecotype (urban and rural) over 14 weeks. Loess was used for data visualization and not analysis. Urban birds began molting and molted at a slower rate than rural birds (see below).

- **Urban birds began molt earlier** (rmANCOVA: Urban α = 21.7, Rural α = 19.2; $F_{1,627}$ = 2.16, **p = 0.03**)
- **Rural birds molted at a faster rate during the study** (rmANCOVA: Ecotype*Time; Urban β = -246, Rural β = -327; $F_{1,627}$ = 3.27, **p = 0.0011**)

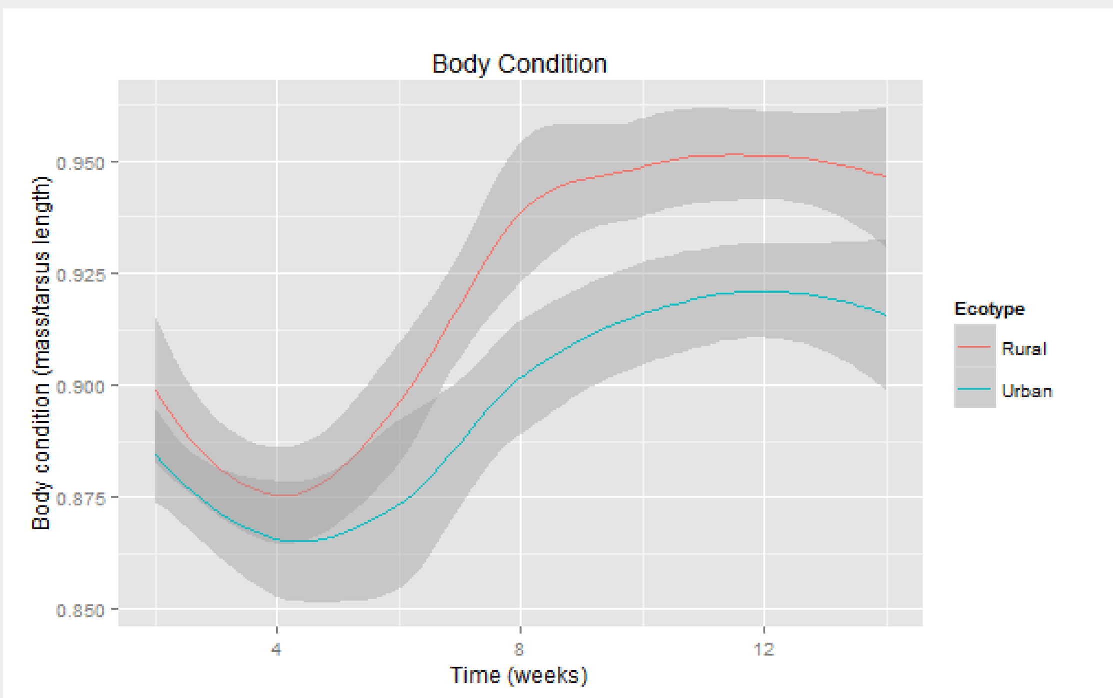


Figure 4. Body condition of urban and rural birds during the course of the study. Urban birds began in poorer condition than rural birds, but urban and rural condition changed similarly over time

- **Urban birds began molt in a poorer body condition** (rmANCOVA: Urban α = 0.887, Rural α = 0.908; $F_{1,627}$ = 4.94, **p <<<0.0001**)
- Urban and rural bird **body condition changed similarly over time** (rmANCOVA: Ecotype*Time; $F_{1,627}$ = 1.06, p = 0.29)

Discussion

- **Molting urban birds are in significantly poorer body condition** than molting rural birds, though (contrary to what we predicted) they started molting earlier
- As body condition did not change differently between urban and rural populations, this **suggests body condition does not mediate differences in molt progress**
- Previous work in this study system during both the breeding and early molt season found no differences in body condition between urban and rural birds[4,5]. This suggests there may be significant inter-annual and inter-seasonal variability in body condition
- Exposure to **long photoperiods** (which are further prolonged in the city) causes upregulation of **prolactin** production, which may be responsible for inducing both photorefactoriness and molt onset[6], potentially explaining why urban birds began molting earlier. Increased **glucocorticoids** could lead to suppressed molt rate
- Increased **ambient temperatures**, like those produced by the urban heat island, also induce early onset of molt[7], giving another possible mechanism for why urban birds began molting earlier
- There **may be weaker selection for urban birds to complete molt in a concise manner**, as urban areas stay warmer throughout the year, birds have plenty of solid cover from rainfall, and consistent food resources
- Conversely, rural birds likely have to time molt to coincide with the increased resource availability of the monsoon season
- May have even stronger fitness implications for urban **migratory birds**, as disrupted molt can hamper flight performance

Conclusions and Future Analyses

- We are currently collecting data on **the temporal development of ornamental plumage coloration** in urban and rural areas. Urban/rural differences could potentially affect social interactions (e.g. intrasexual dominance ranking) leading up to the breeding season
- Overall, these results are the first to demonstrate that molt, a key condition-dependent life-history trait in birds, can be affected by the urban environment

References and Acknowledgments

References

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Acknowledgements

We thank S. Taubel, N. Munoz, J. McKenna, F. Iqbal, J. Bruening, S. Jordan and M. Cook for their assistance with fieldwork. This work was fully supported by the Arizona State University Citizen Science and Citizen Engagement (CSCE) grant program.