

Individual, population, and community responses of small mammals to the Atlanta urban-to-rural gradient

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Effects of urbanization – Overview

- Environmental changes
 - Habitat fragmentation
 - Increased noise, light, temperature
 - Driven by human population density and other choices
- Changes in resource availability
 - Human food waste, fewer natural food sources → caloric surplus?
 - Altered predation risks
- Possible consequences for small mammals
 - Species and community diversity
 - Individual performance and morphology



Small mammals in the big city

- Small mammals are excellent study system for effects of urbanization
 - Numerous and diverse
 - Relatively easy to sample
 - Responsive to local conditions
 - Ecosystem services
 - Baseline biology well understood

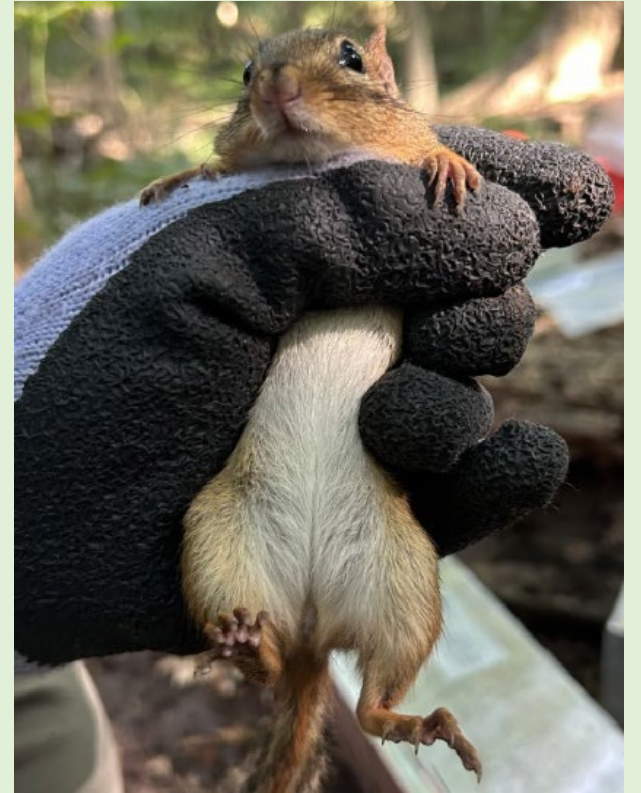


Objectives and Hypotheses

Main objectives:

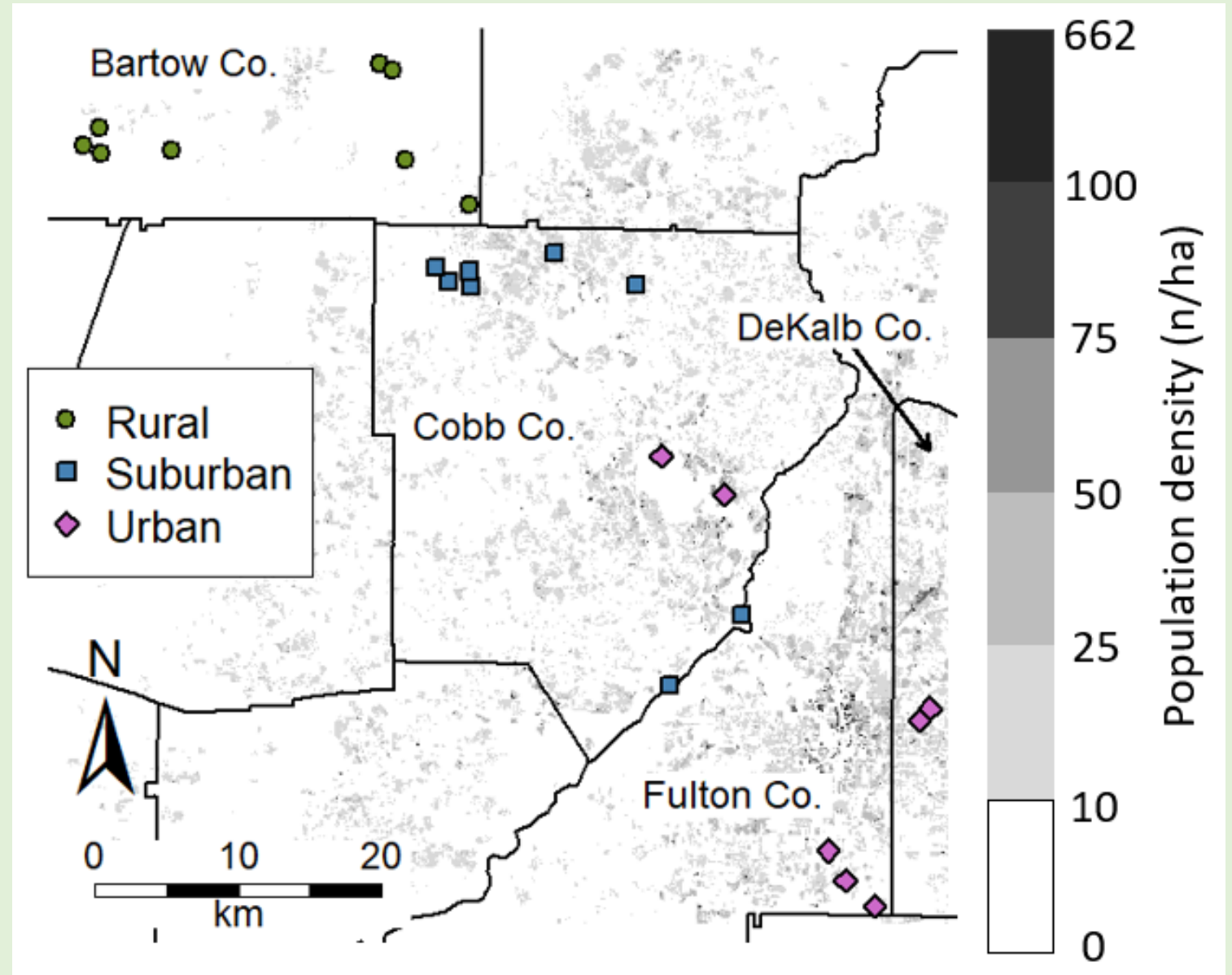
1. Determine what geospatial, environmental, and socioeconomic factors affect small mammal community structure along an urban-rural gradient.
2. Investigate how urbanization affects small mammal morphology and physiology

Our **main hypothesis** was that urbanization alters small mammal ecology across levels of organization, from individuals to communities.



Methods: small mammal sampling

- Trapped small mammals at 23 sites along urban-to-rural gradient from Atlanta to Bartow County.
- 14,720 total trapnights (640 per site)
- Individuals caught:
 - Identified to species
 - Weighed and measured
 - Assessed sex and reproductive status
 - Blood samples for lipid and hormonal assays
 - Tagged and released



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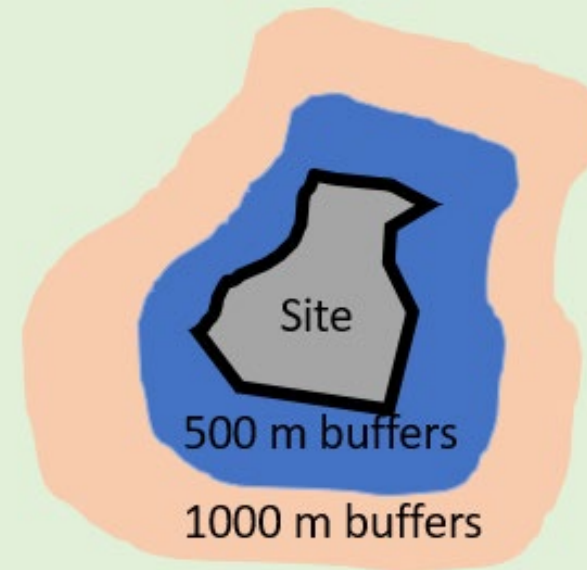
Methods: variable collection

- Local habitat variables, plant cover collected in field
- Spatial characteristics and land cover surrounding of each site measured with GIS
- Socioeconomic variables obtained from U.S. Census Bureau
- Human population from WorldPop project
- Socioeconomic and environmental variables related to 1000 m buffers around sites



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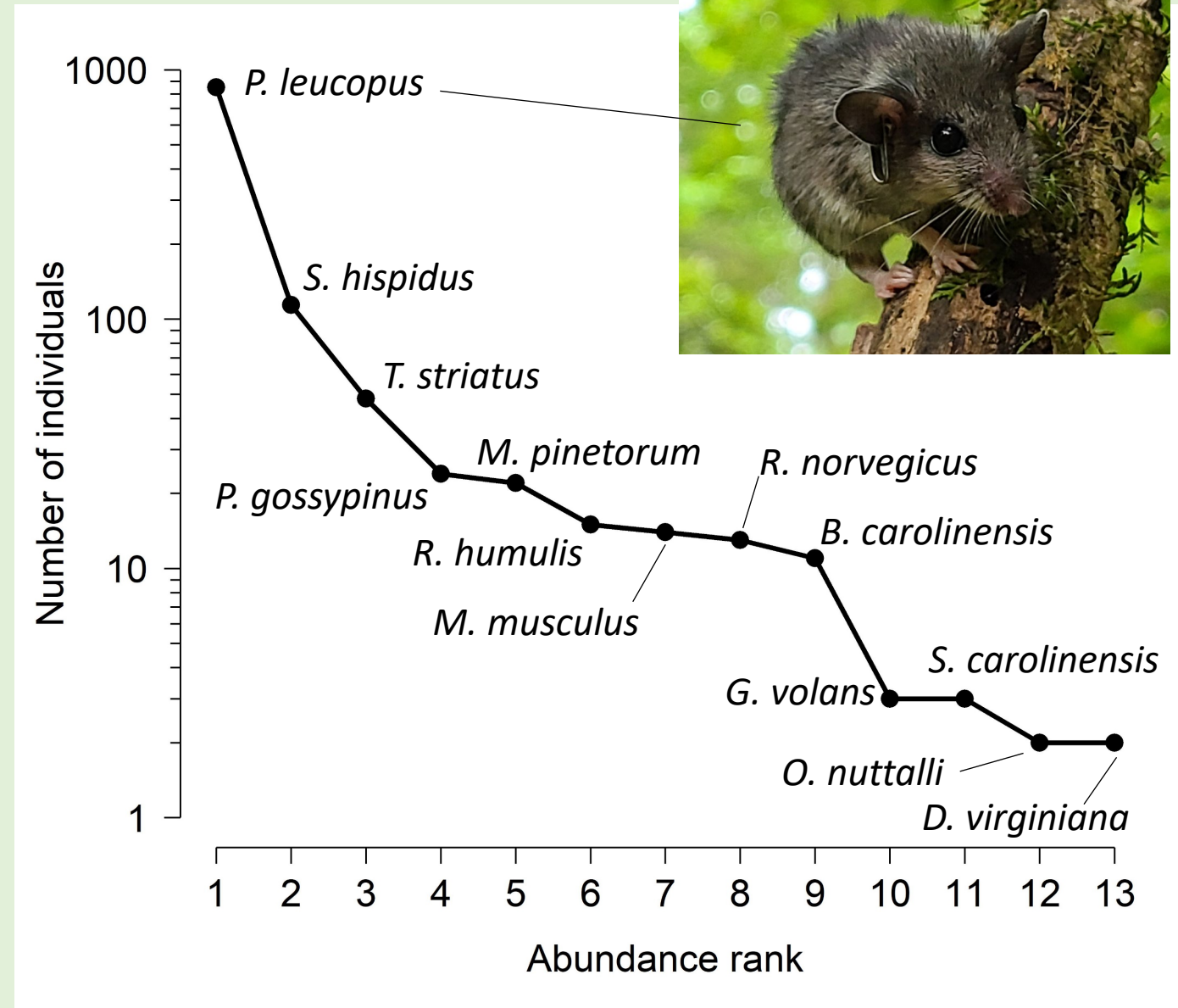
Methods: blood analysis

- Drew blood from submandibular vein
 - Measured TRIG and CHOL using CardioChek Plus in field
 - Took blood sample for later CORT analysis
- Pregnant and juvenile animals excluded from blood sampling
- Total: 118 lipid panels, 89 serum samples



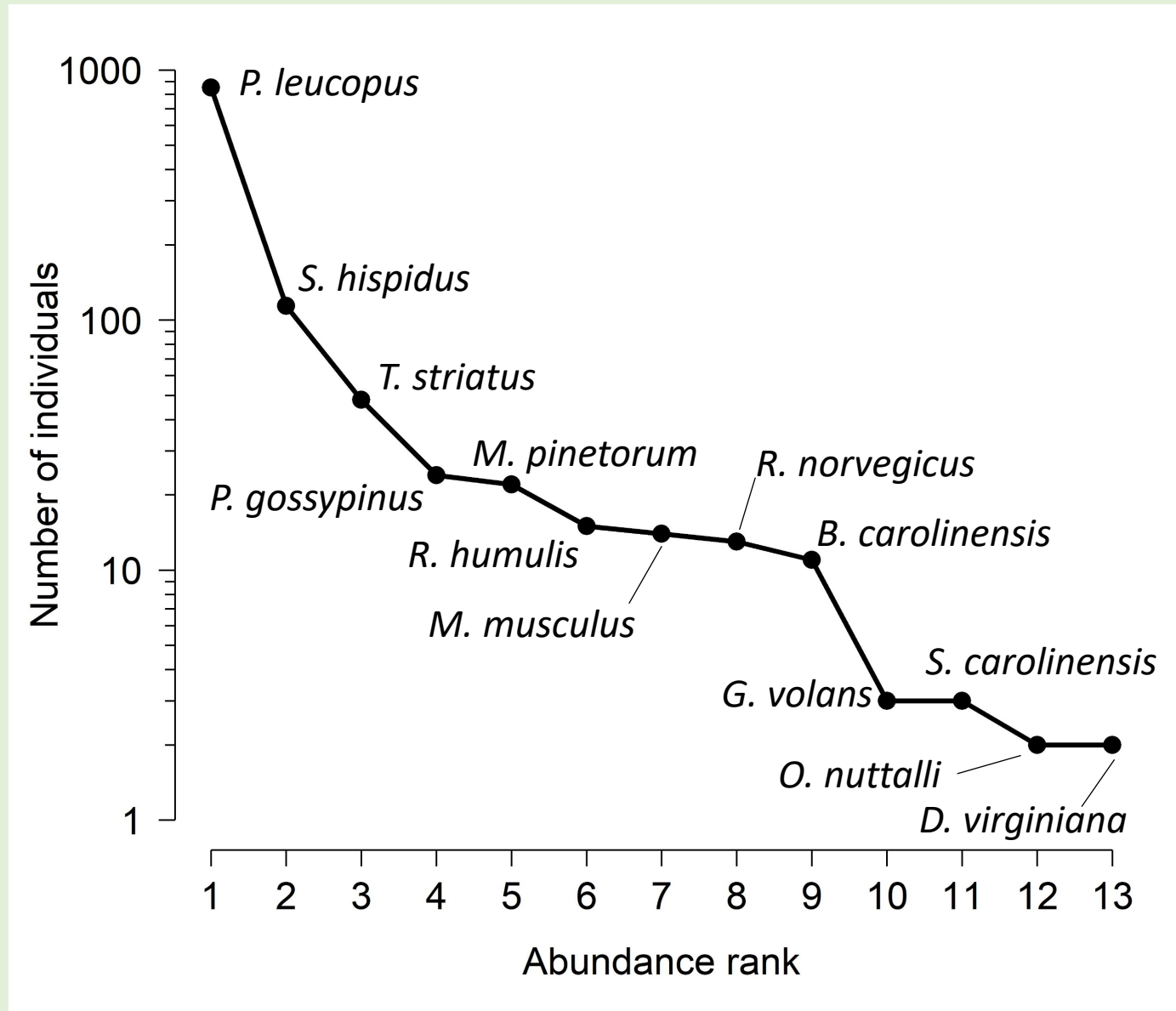
Results: capture summary

- 1,135 total captures of 13 species
 - 7.7 captures / 100 trap-nights
- Captures dominated by *P. leucopus*
 - Few human commensals (*M. musculus*, *R. norvegicus*)
 - Excluded *D. virginiana* from analysis, included all others
- Used observed movement distances and MNKA to calculate population density at each site



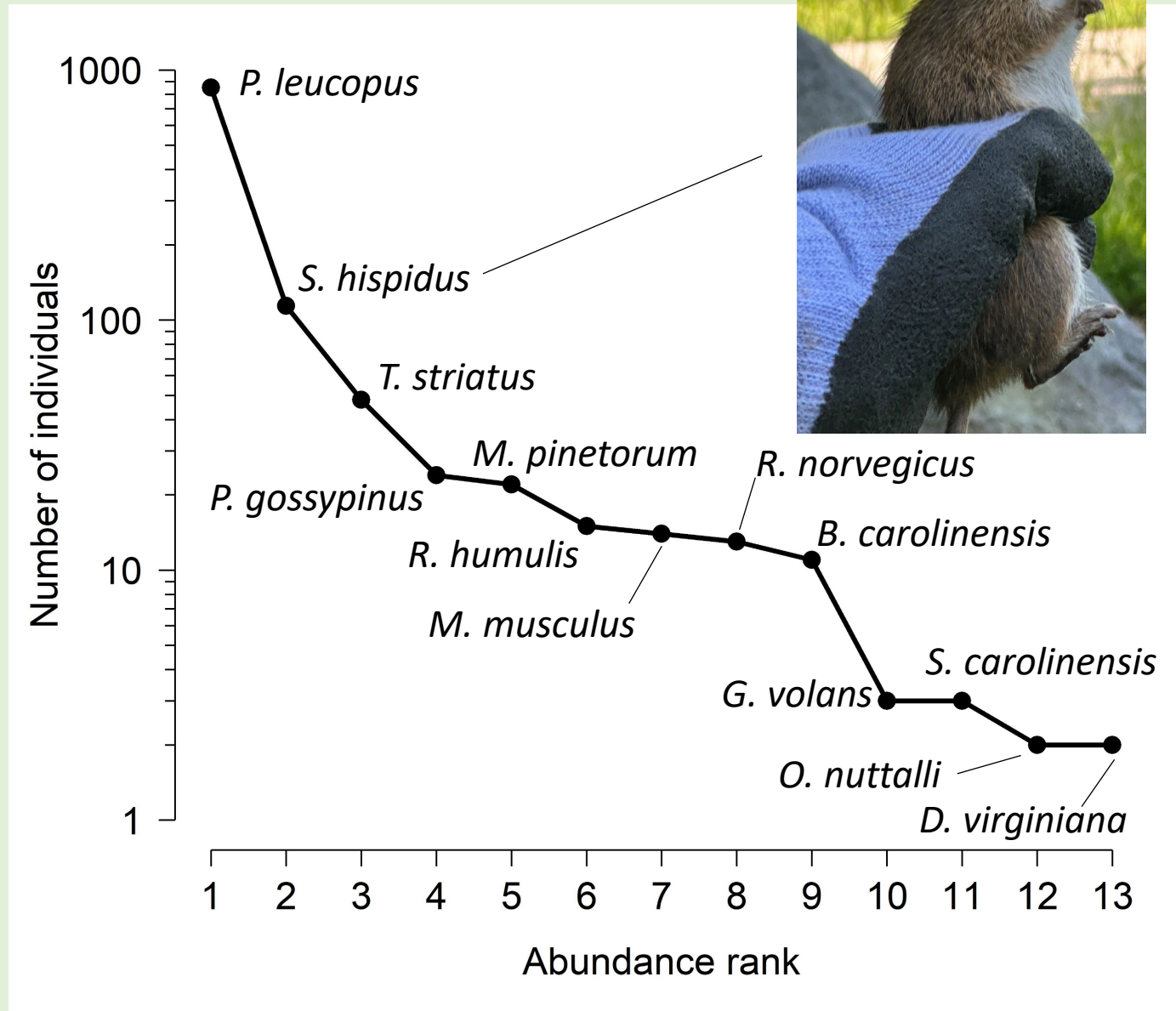
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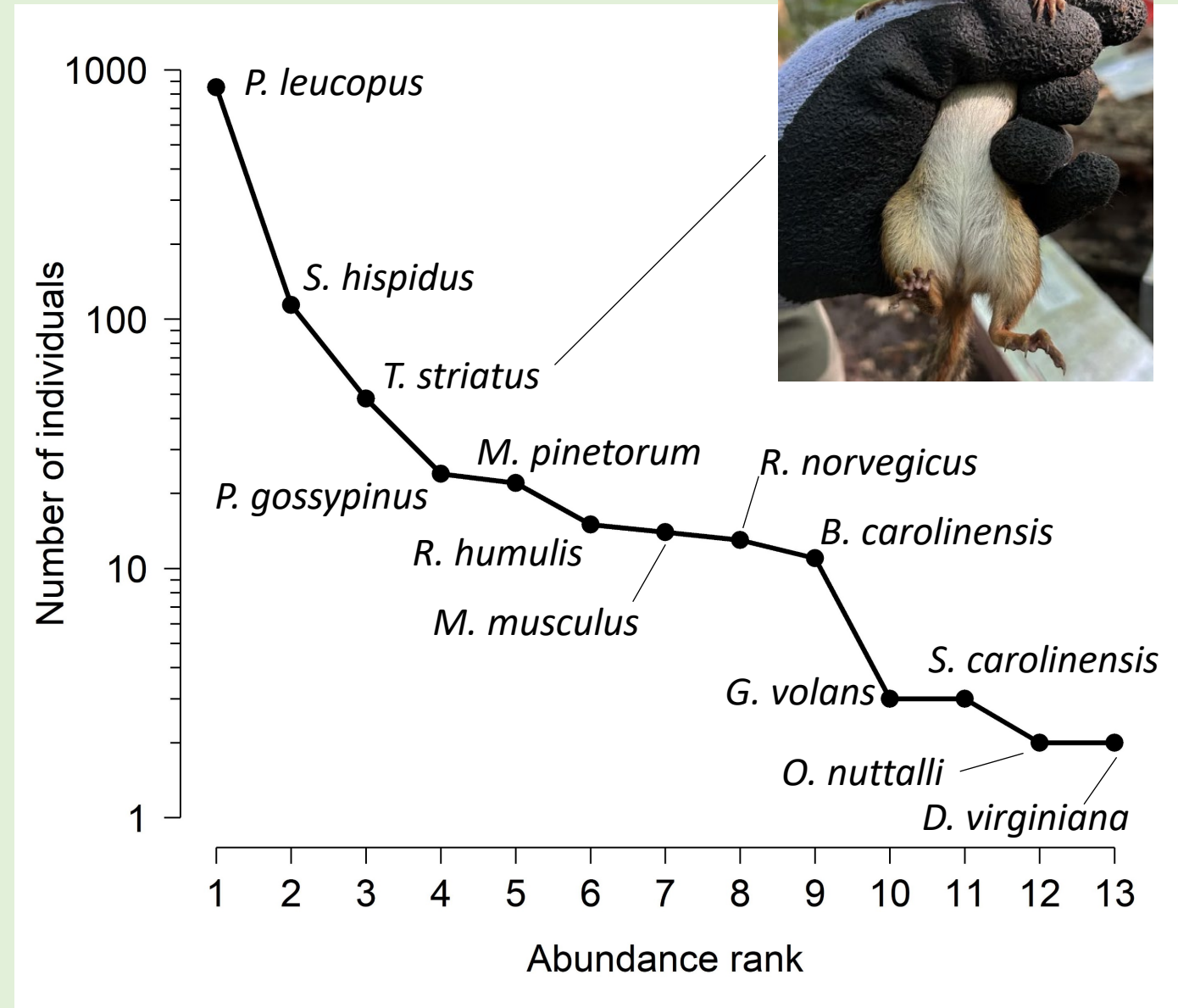
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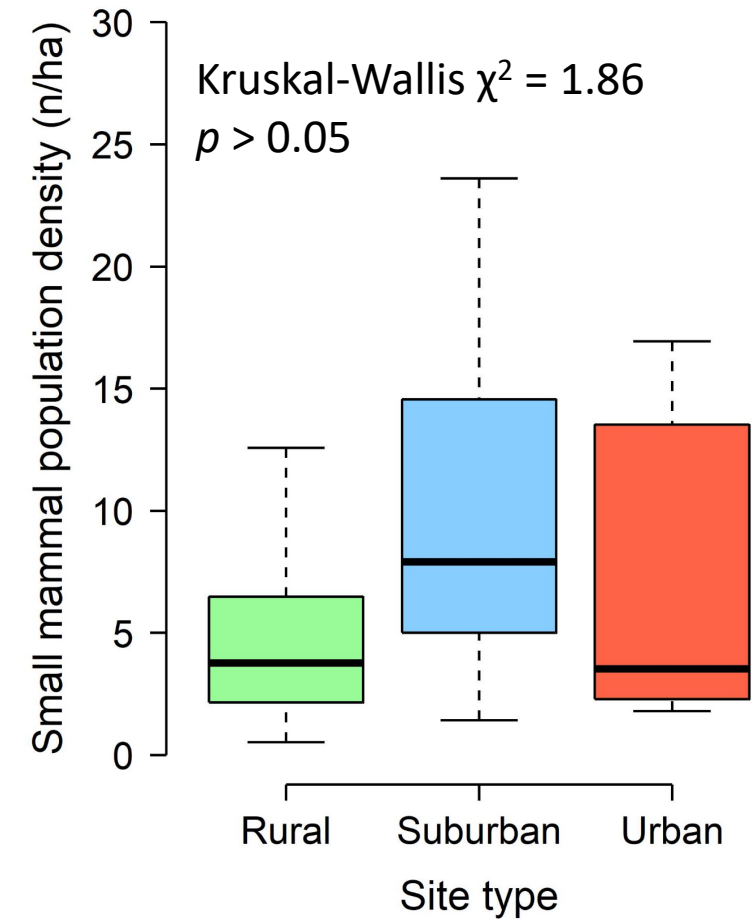
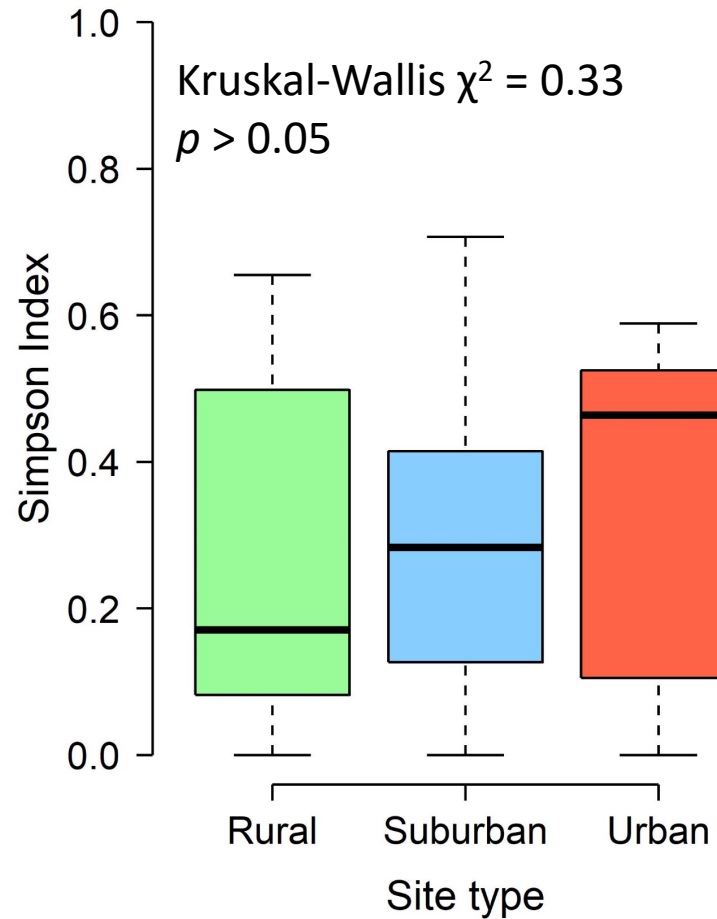
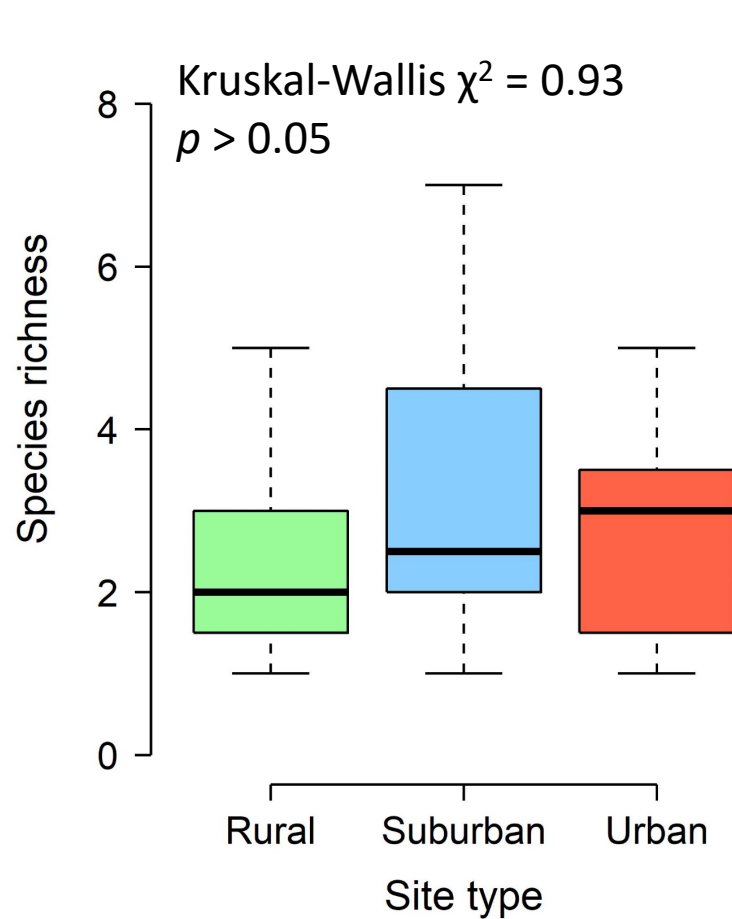


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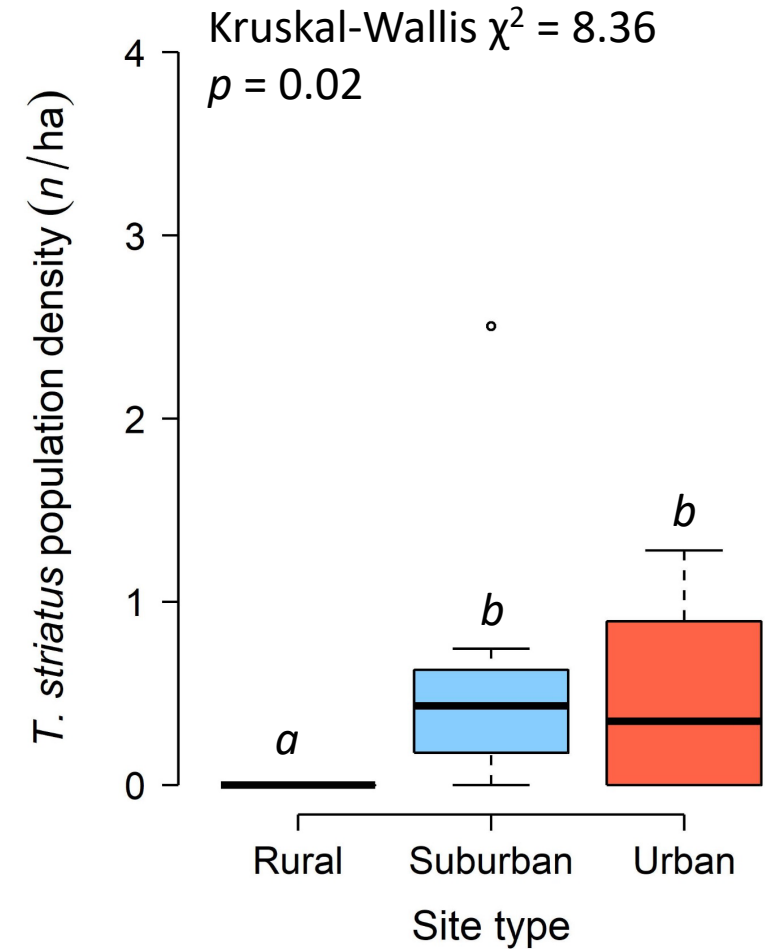
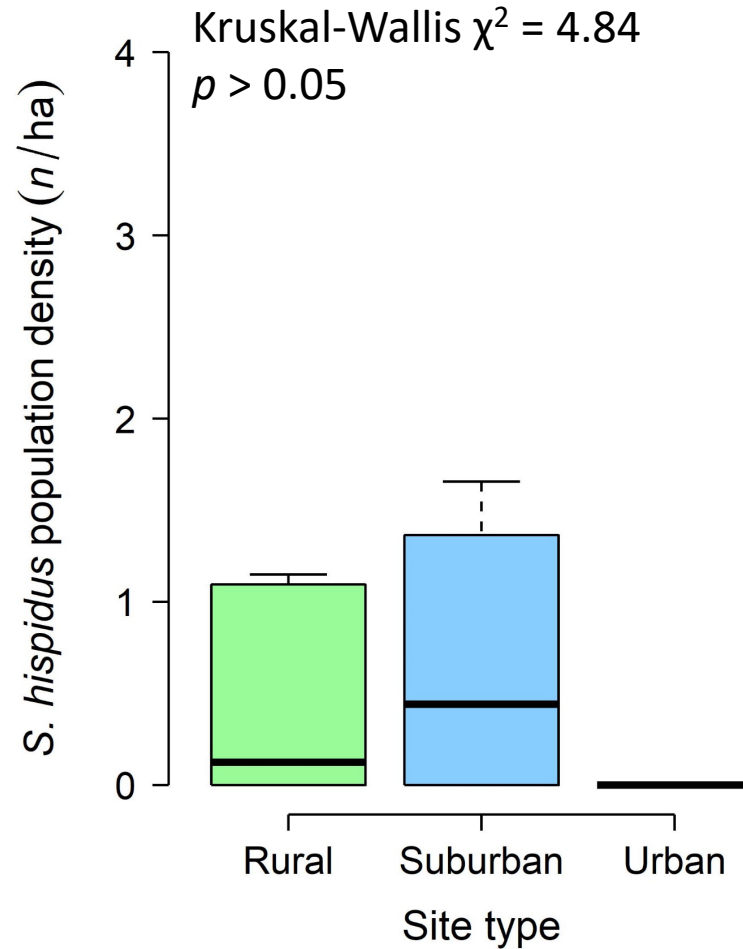
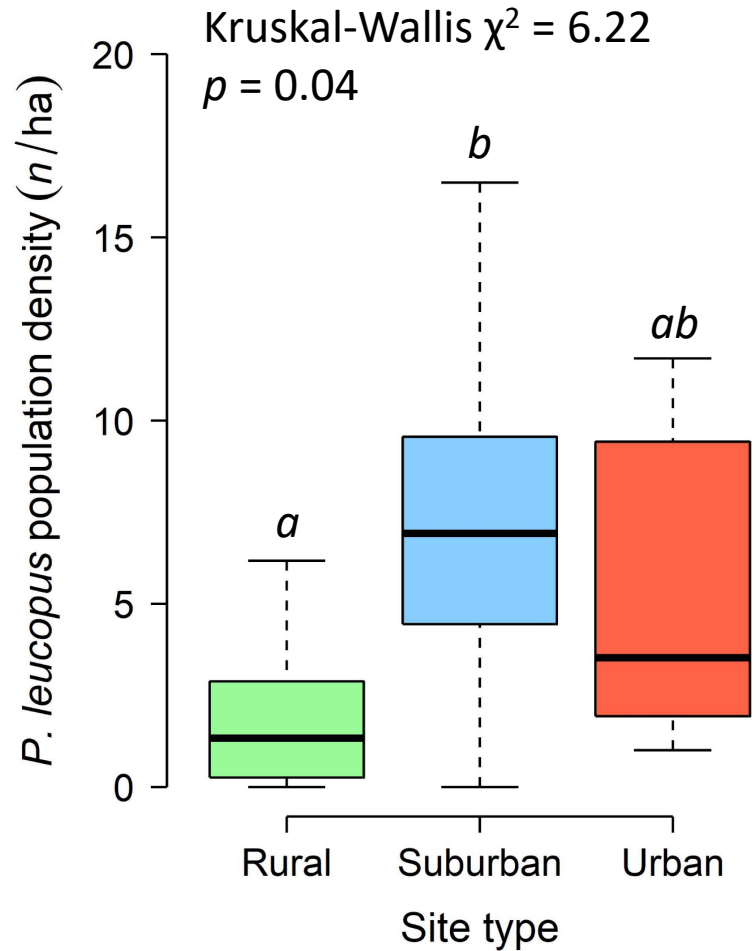
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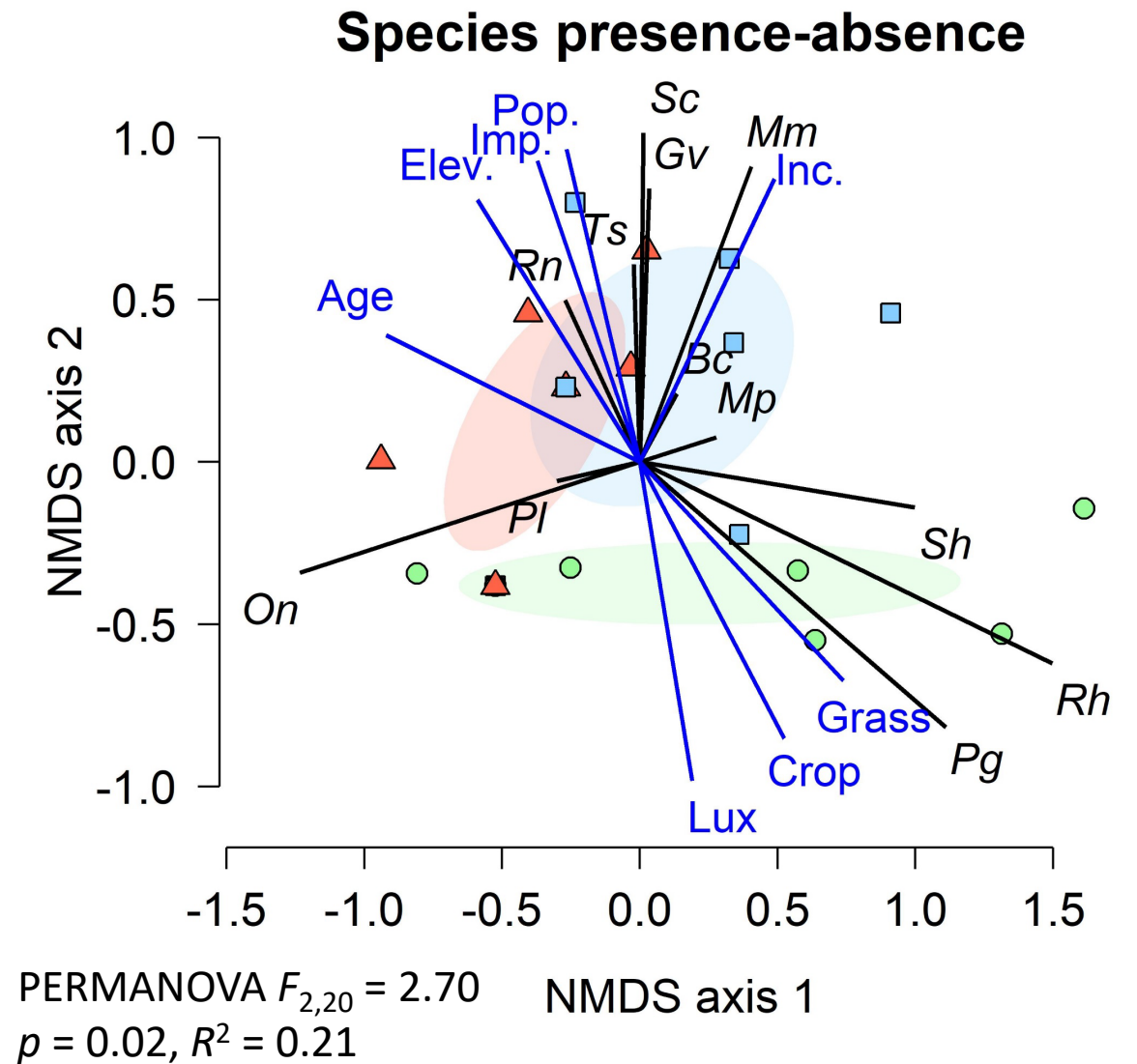
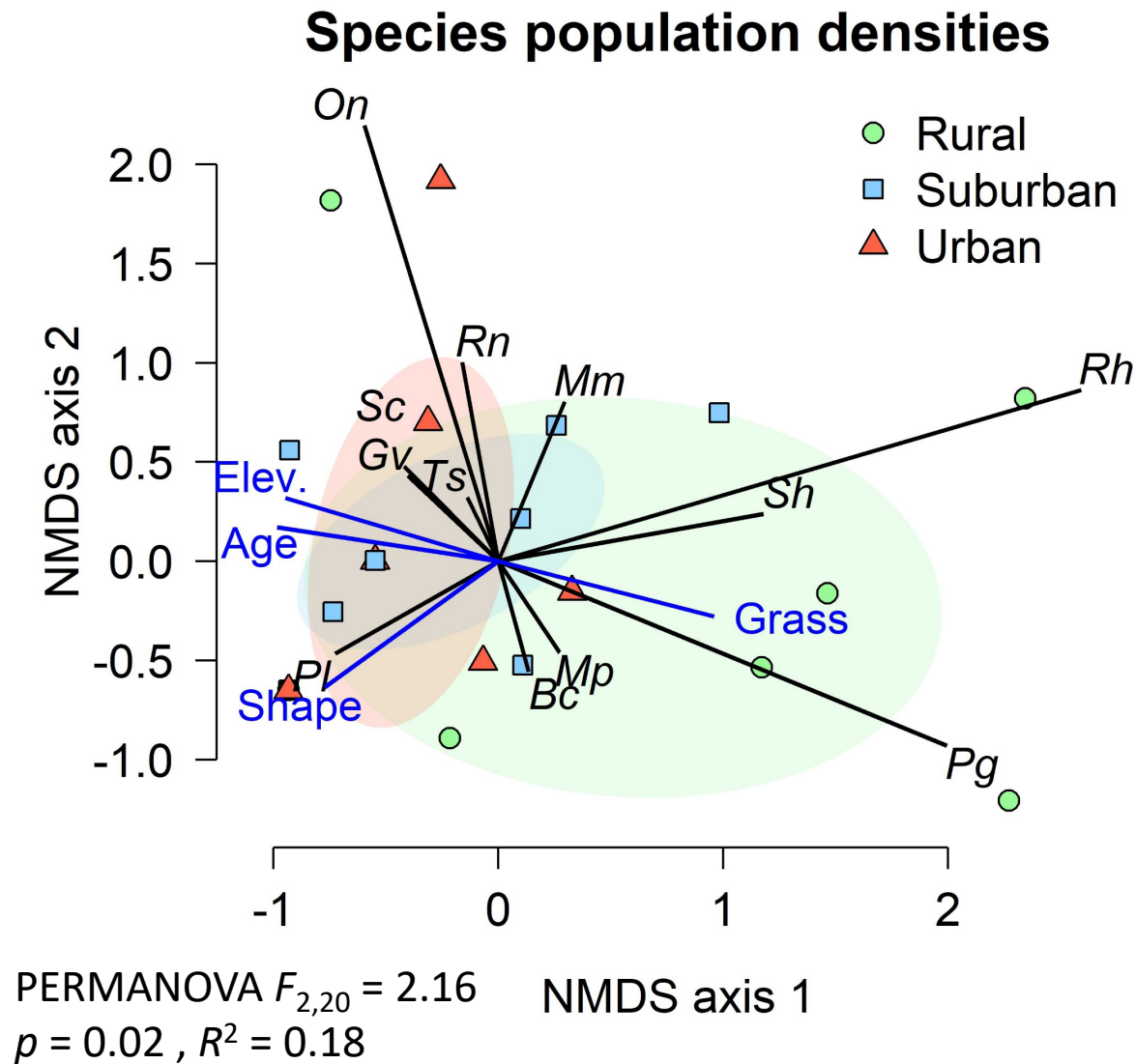
Results – Community metrics



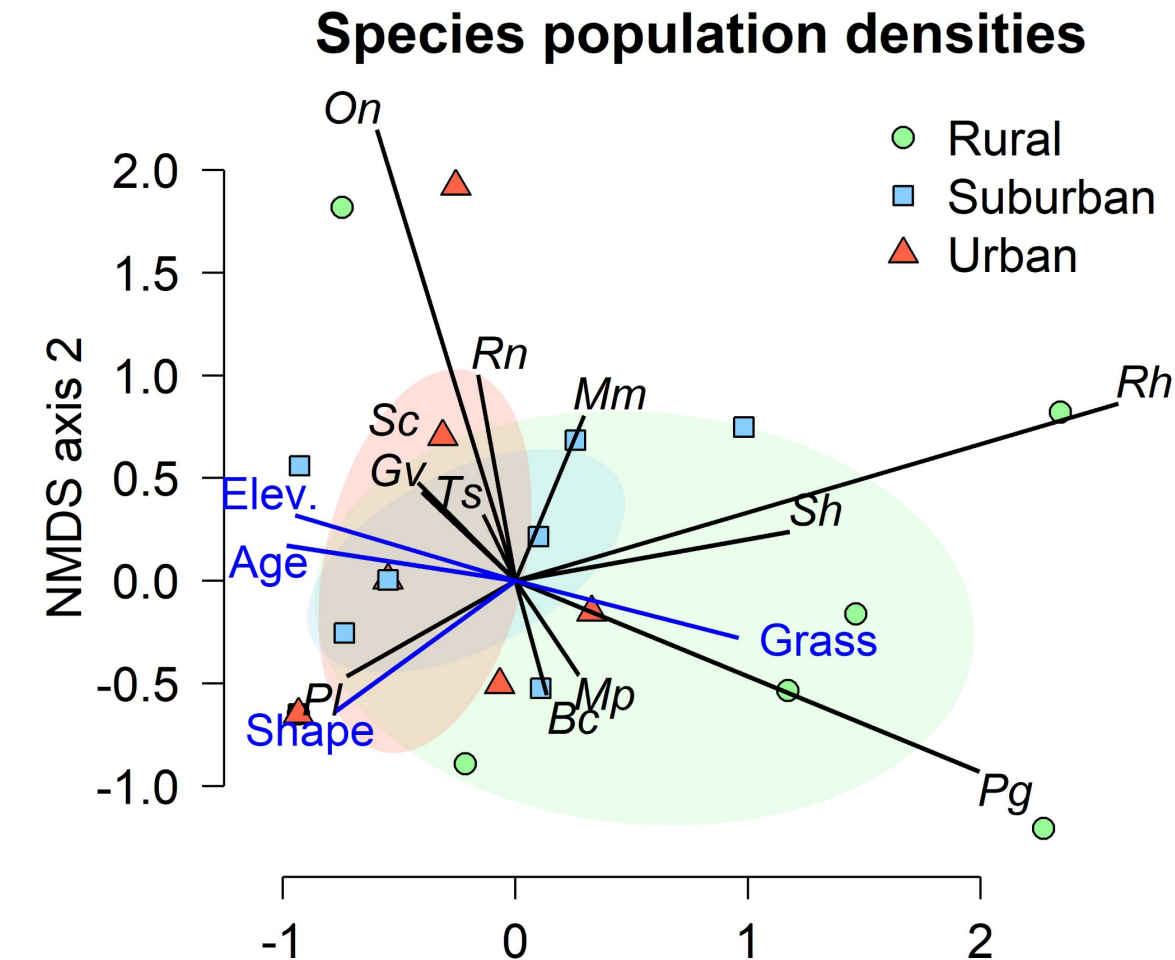
Results – Population densities



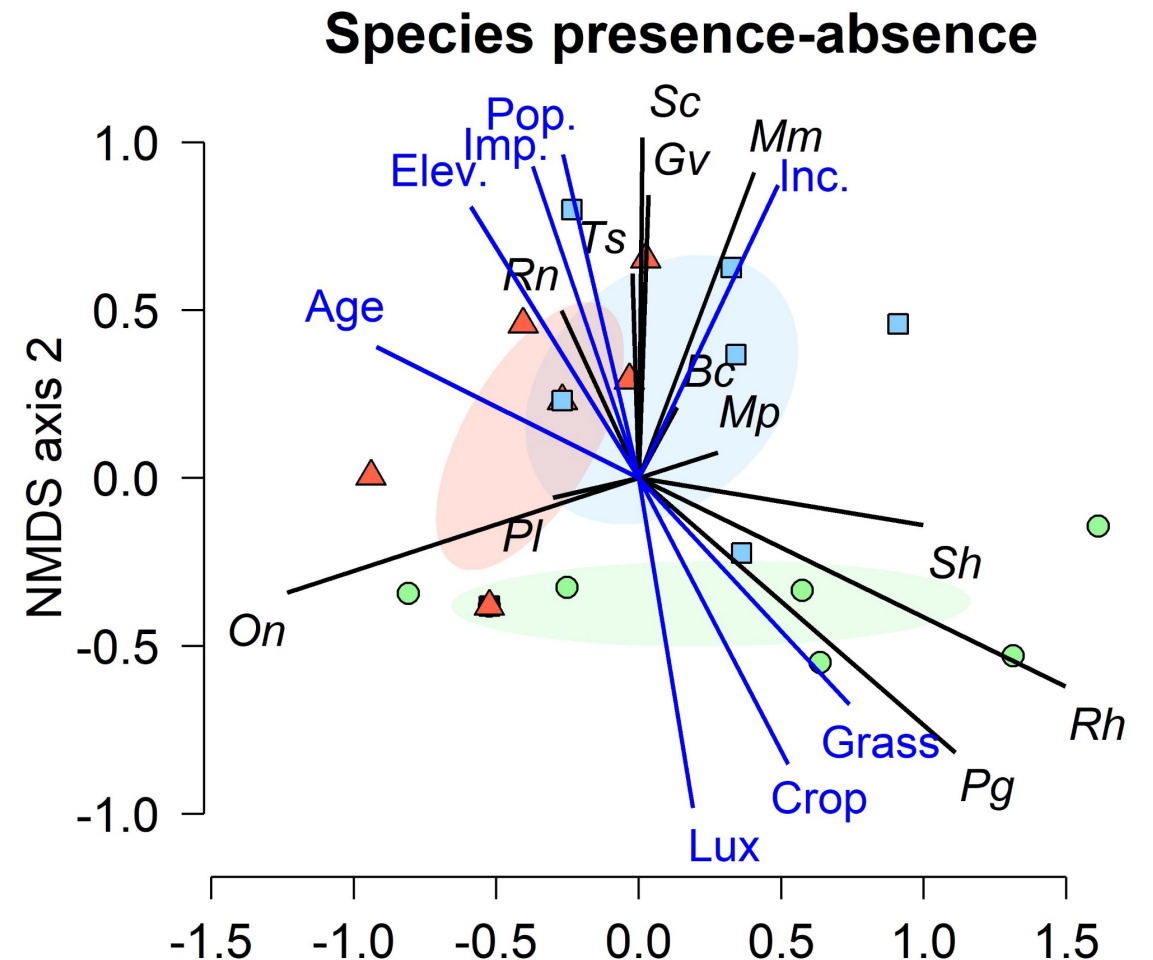
Results – Community structure



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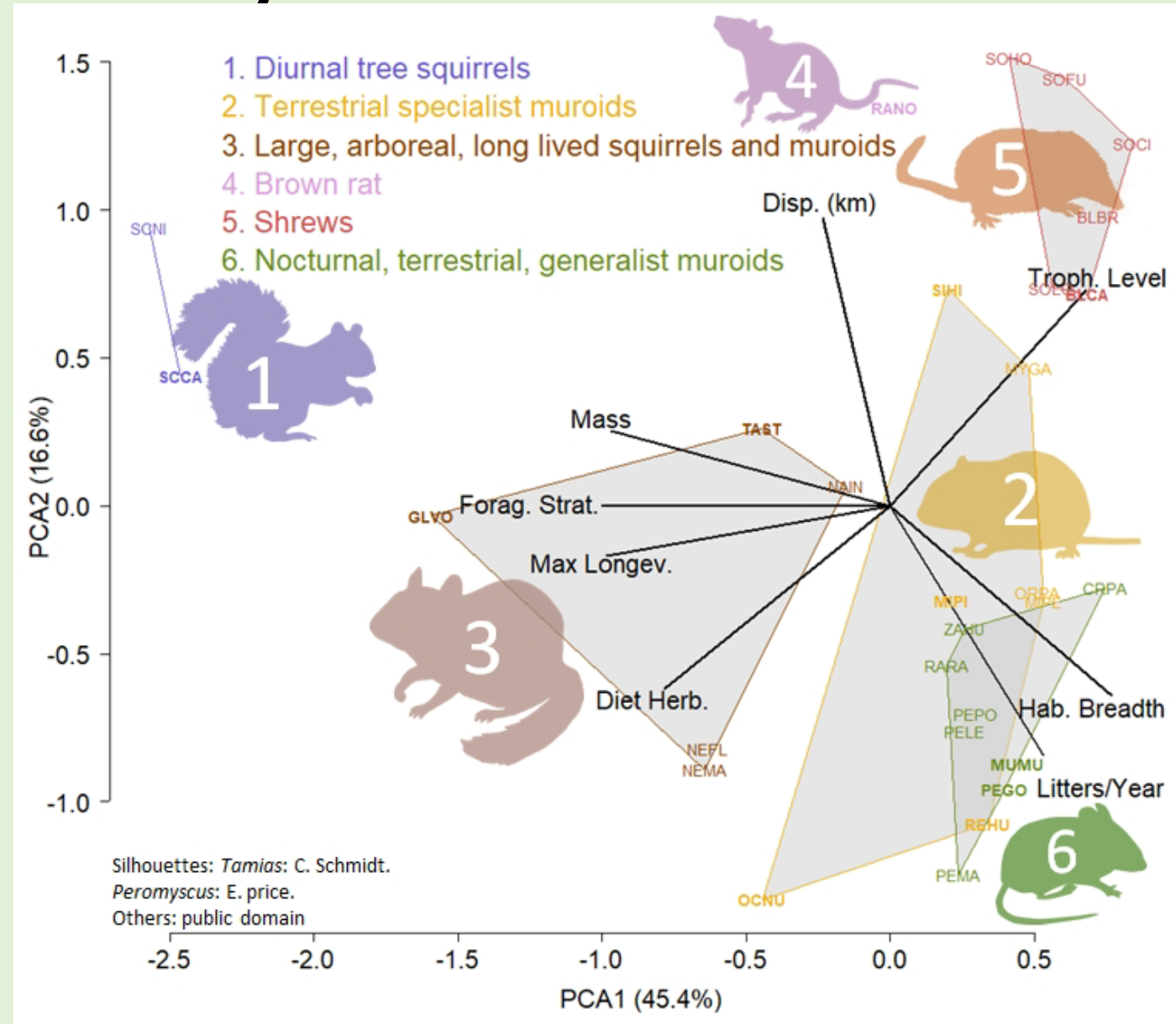
PERMANOVA $F_{2,20} = 2.16$ NMDS axis 1
 $p = 0.02$, $R^2 = 0.18$



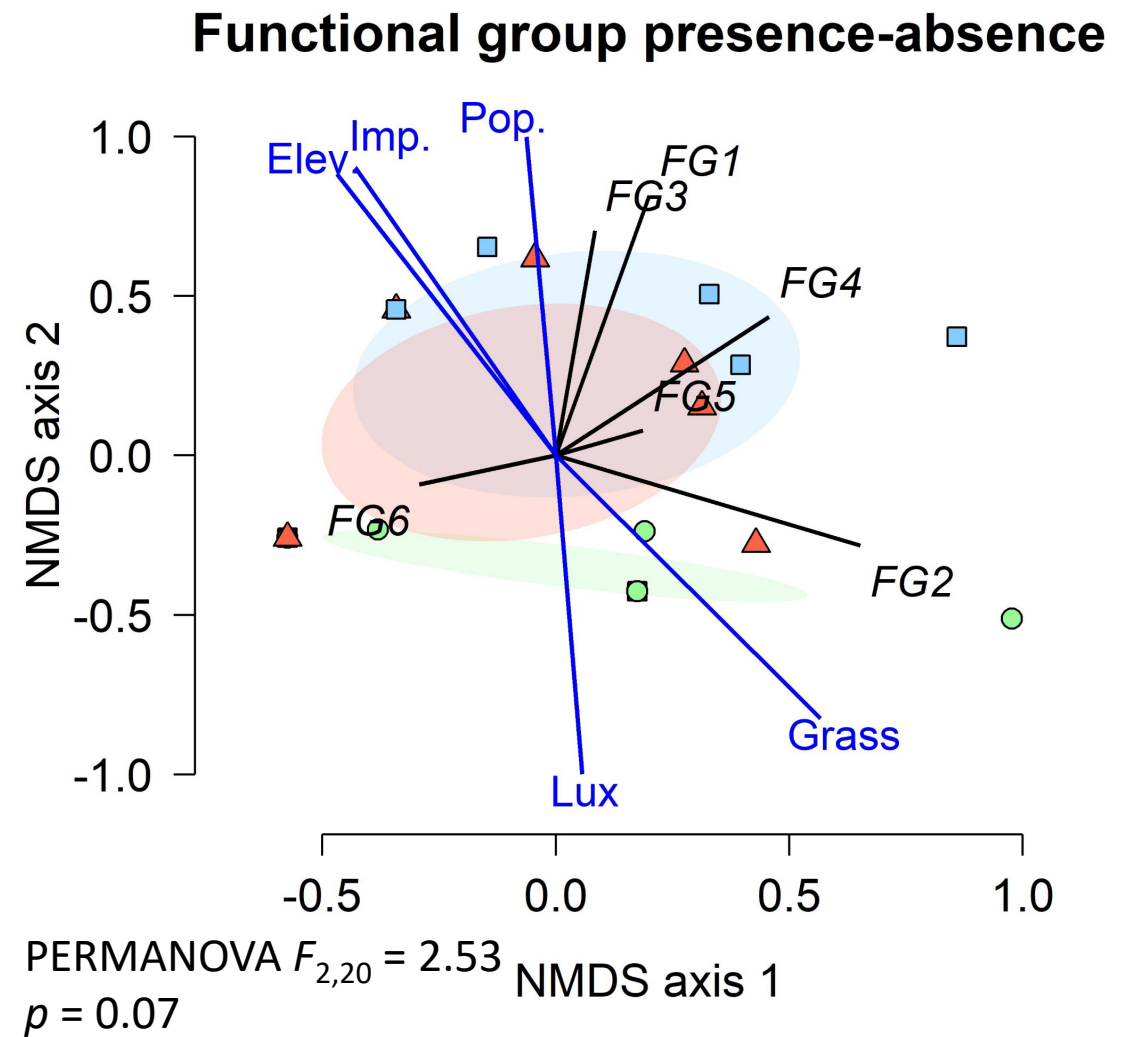
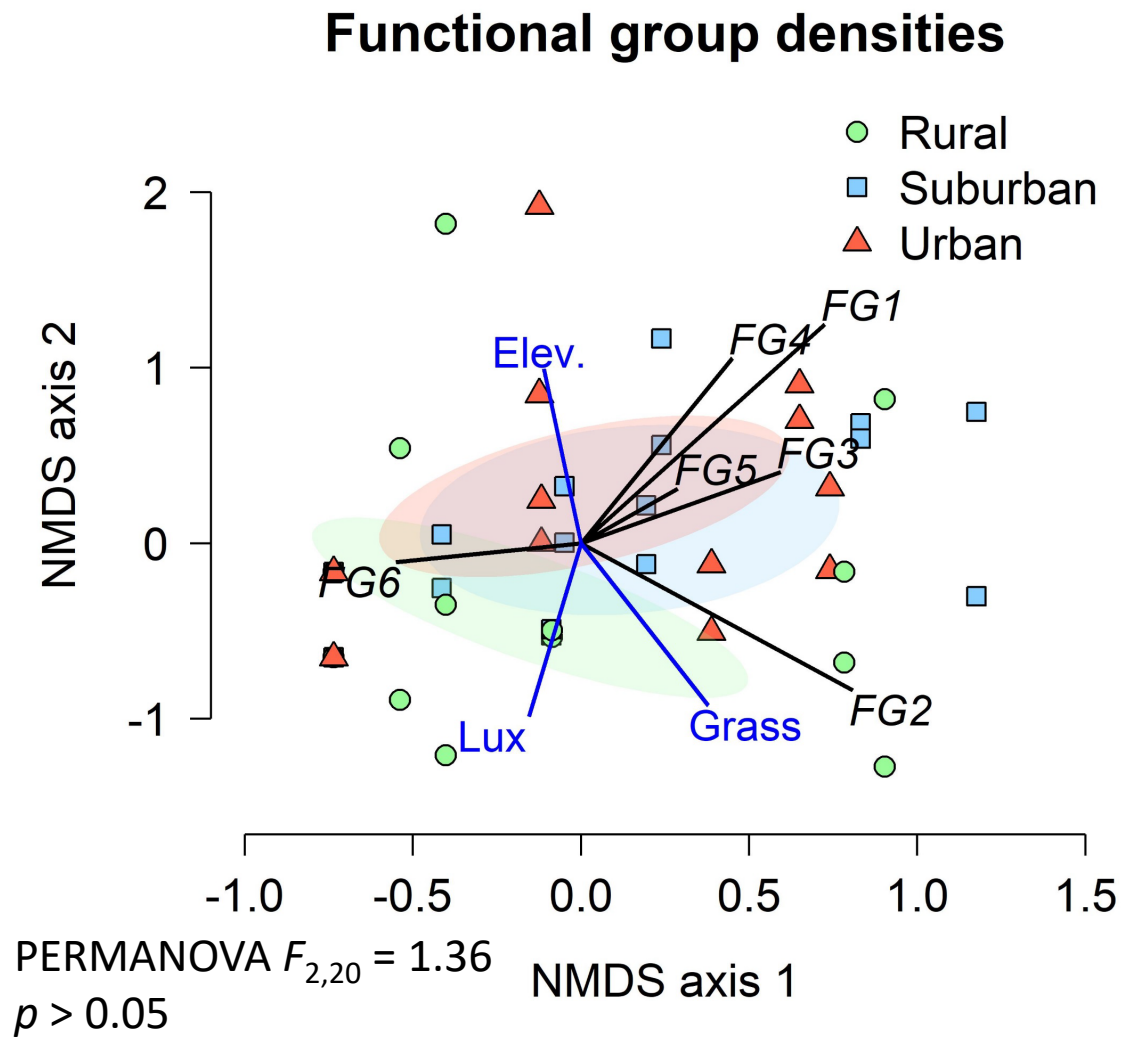
PERMANOVA $F_{2,20} = 2.70$ NMDS axis 1
 $p = 0.02$, $R^2 = 0.21$

Results – Functional diversity

- Used *k*-means clustering to identify functionally similar groups of species (“functional groups”)
- Identified six groups among Georgia small mammals
- Calculated population densities of each functional group at each site

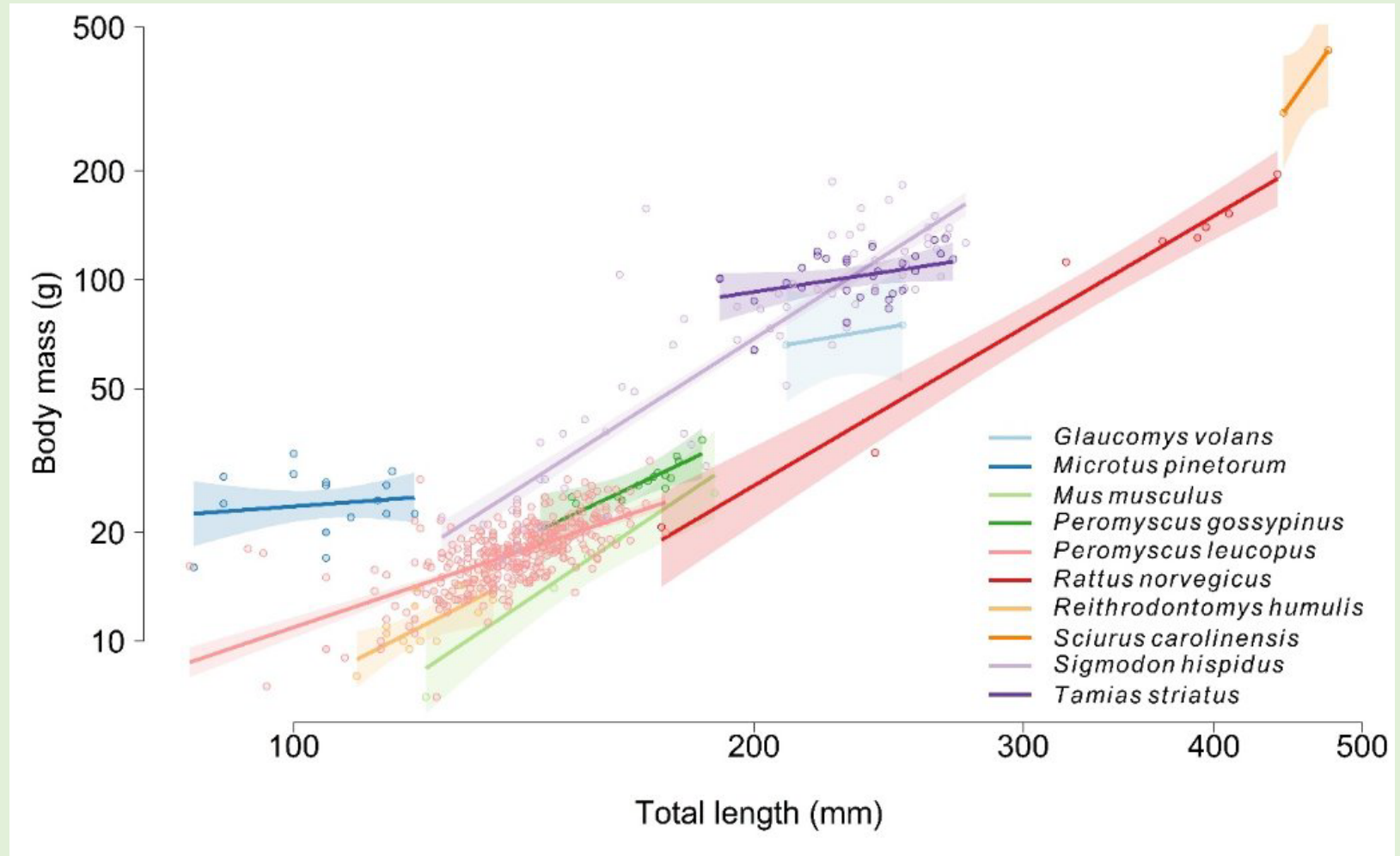


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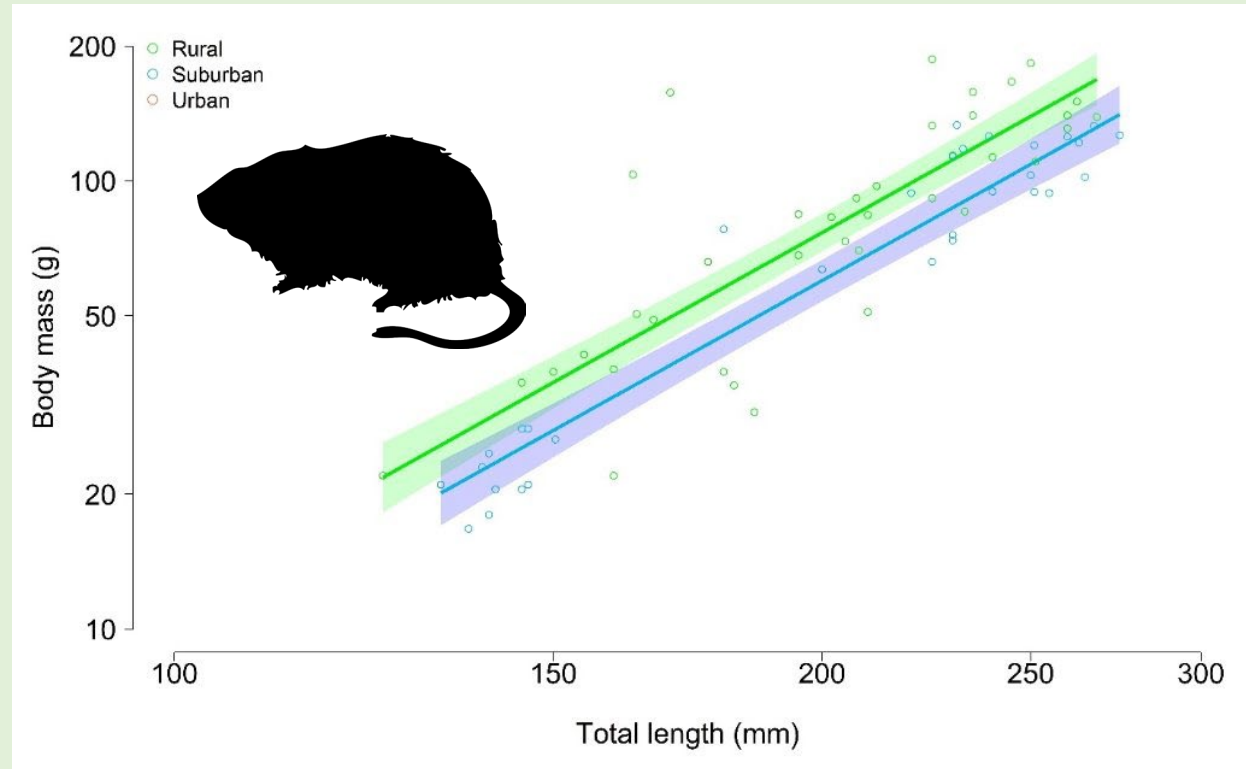
Results: Mass-length allometry

- Fit power law of mass vs. length, with species-specific slopes
 - Model $R^2 = 0.91$ (omnibus $F_{10,557} = 575.60$, $P < 0.01$).
- Then, compared residuals of this relationship to site characteristics (incl. urbanization)



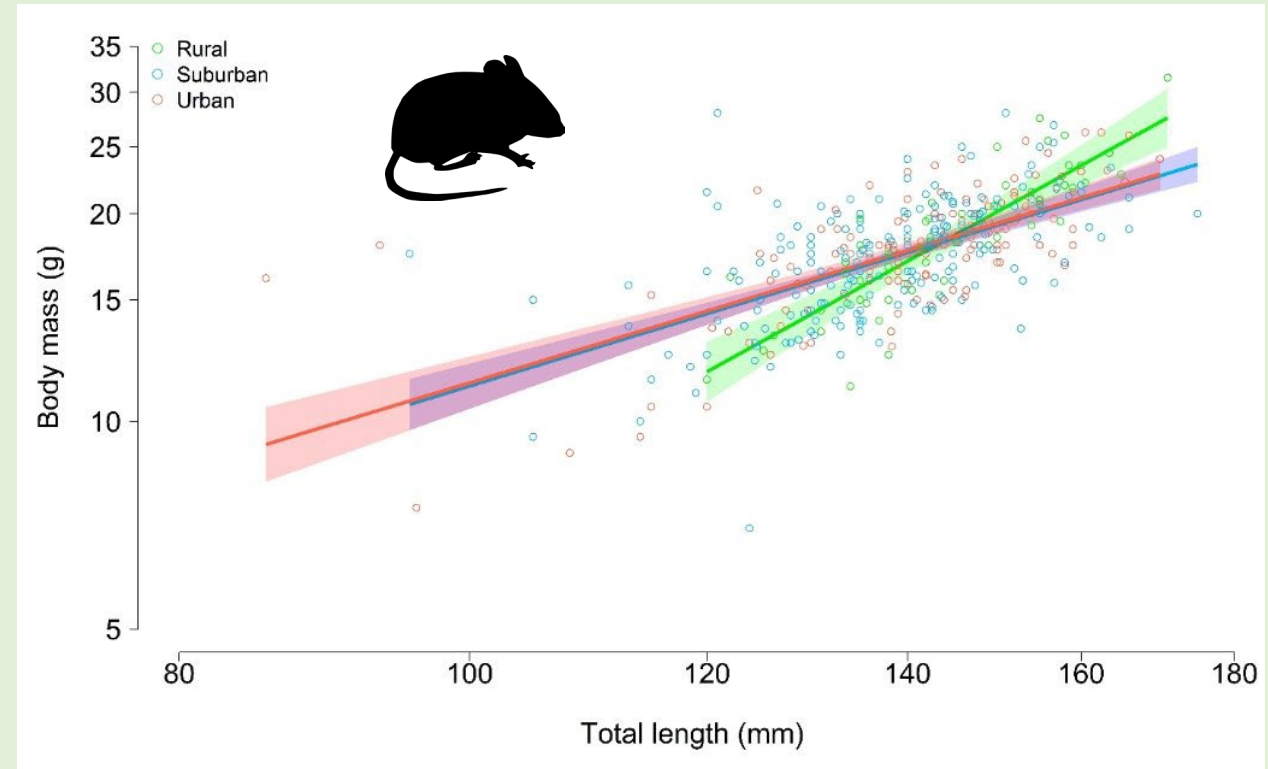
Results: Mass-length allometry

Hispid cotton rats (*S. hispidus*)



Body mass and total length of hispid cotton rats (*S. hispidus*):
Model $R^2 = 0.807$ (omnibus ANOVA $F_{3,65} = 95.73$, $P < 0.01$)

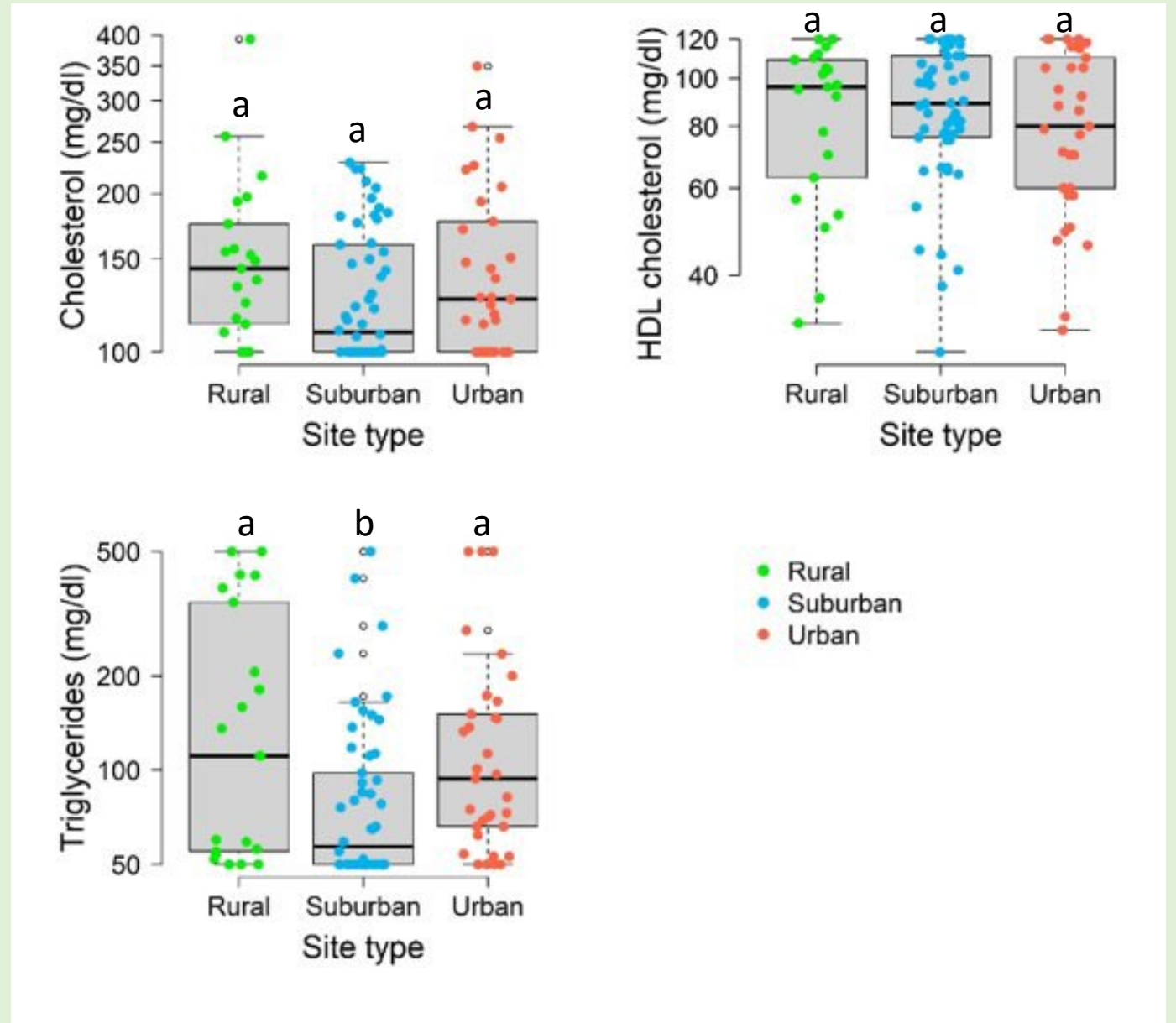
White-footed mice (*P. leucopus*)



Body mass and total length of white-footed mice (*P. leucopus*):
Model $R^2 = 0.448$ (omnibus ANOVA $F_{5,401} = 66.8$, $P < 0.01$)
(Silhouette: E. Price).

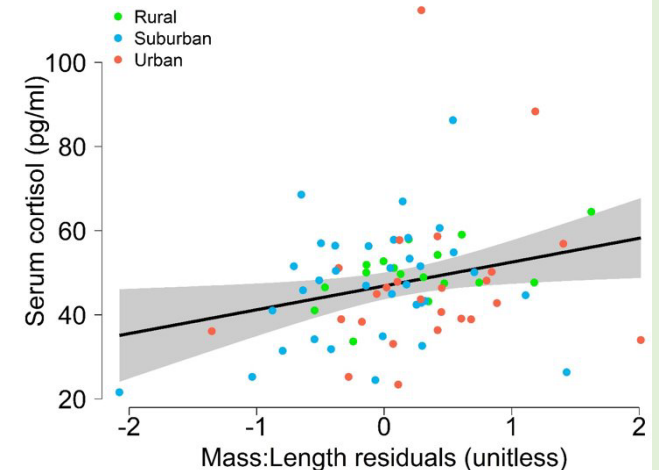
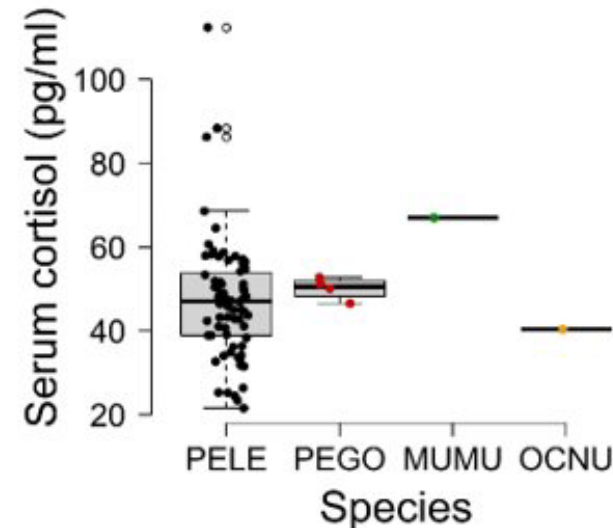
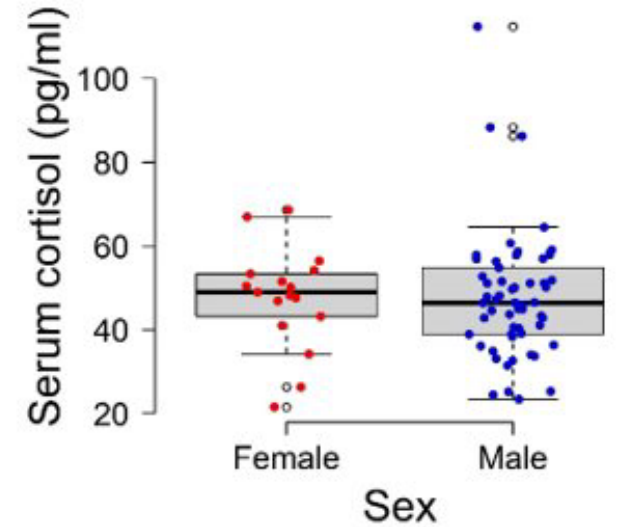
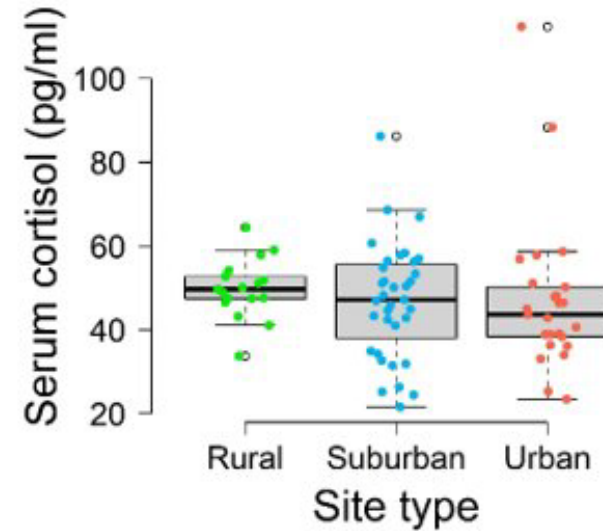
Results: Body condition

- TRIG, but not CHOL or HDL, affected by urbanization:
 - Kruskal-Wallis tests:
 - Triglycerides (TRIG): $\chi^2 = 11.805$, d.f., $P = \mathbf{0.0027}$
 - Cholesterol (CHOL): $\chi^2 = 4.331$, 2 d.f., $P = 0.1147$
 - High density lipoprotein (HDL) cholesterol : $\chi^2 = 0.966$, 2 d.f., $P = 0.6169$).



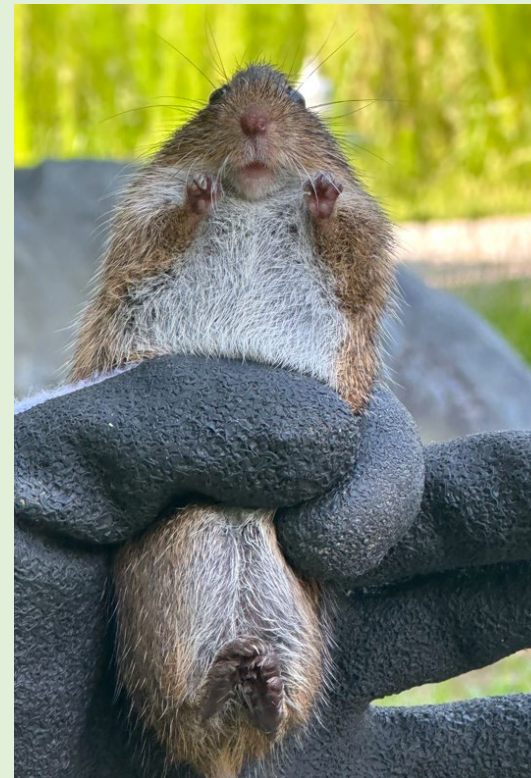
Results: Cortisol levels

- Small mammal serum cortisol (CORT) was not affected by urbanization, species, or sex.
- CORT was weakly related to body size (mass:length residuals) ($F_{1,75} = 5.414$, $P = \mathbf{0.022}$, $R^2 = 0.055$).



Conclusions

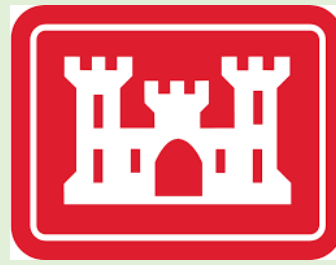
- Small mammal densities driven by several environmental, spatial, and socioeconomic variables
- Urbanization associated with species turnover, but not functional loss.
- Caloric surplus was not evident in morphological or serological data.
- Little redundancy between morphological and physiological indicators of nutritional status.
- No relationship between urbanization and individual stress



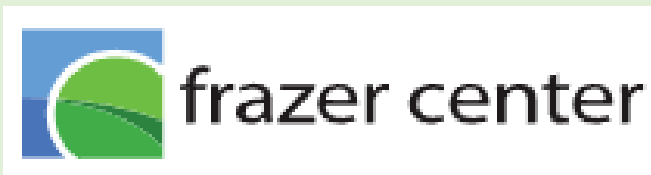
Acknowledgements

Thank you to Kennesaw State University, especially M. Griffin, our undergraduate student researchers, and the organizations below for allowing us to sample their land!

- U.S. Army Corps of Engineers
- Cobb County Parks Department
- Georgia Power at Plant Bowen
- Frazer Forest
- Fernbank Museum of Natural History
- Atlanta Expo Center
- The Conservation Fund



Georgia Power



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Thank you!



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