Linking museum specimens with physiological ecology to model susceptibility to climate change in desert bird communities

Eric Riddell, Kelly Iknayan, Blair Wolf, Barry Sinervo and Steve Beissinger

Museum of Vertebrate Zoology
University of California, Berkeley

iDigBio 2018

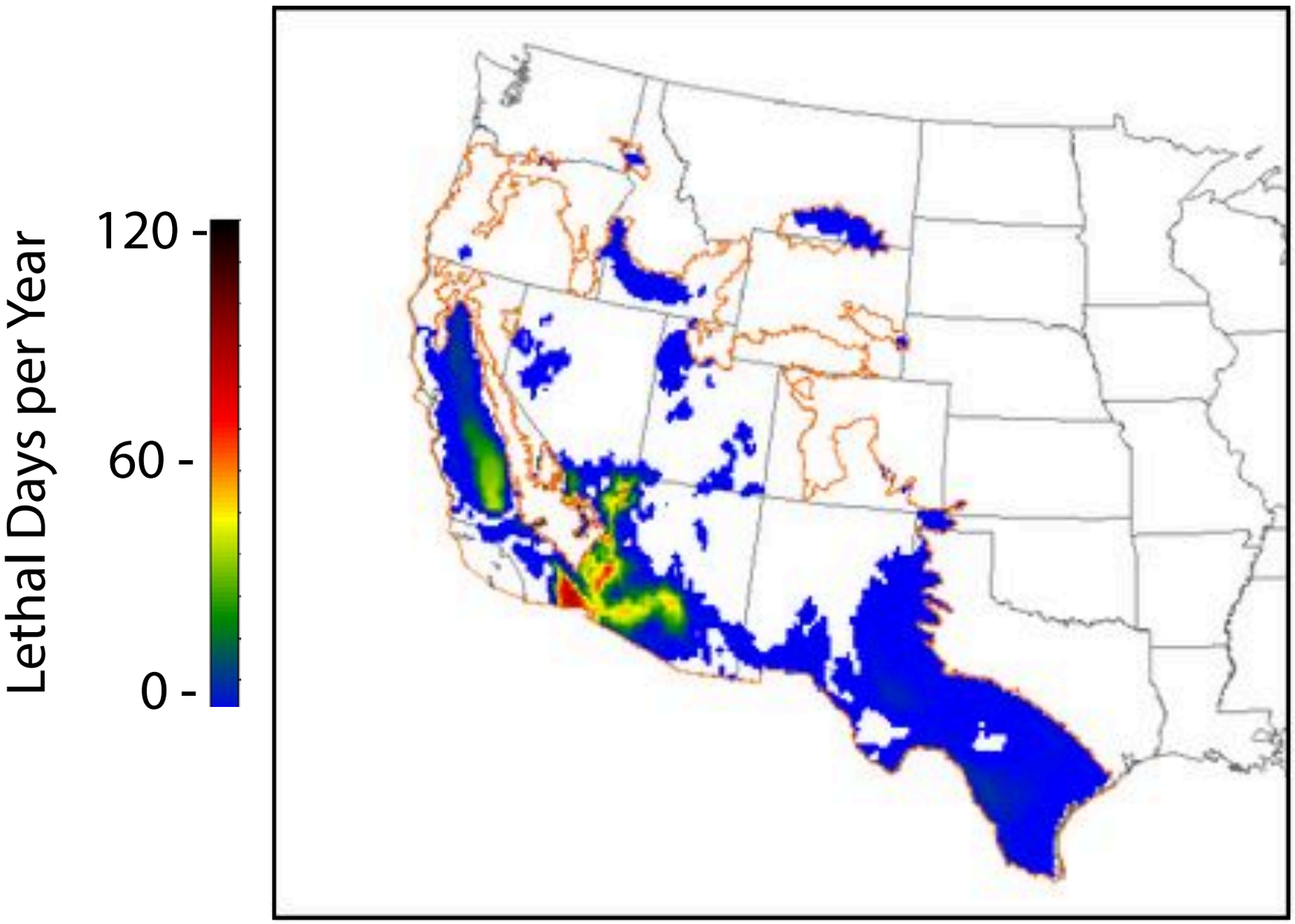
How do physiological traits influence habitat suitability?

"…restricted distributions are likely due to various physiological and psychological aspects…."

Grinnell 1917

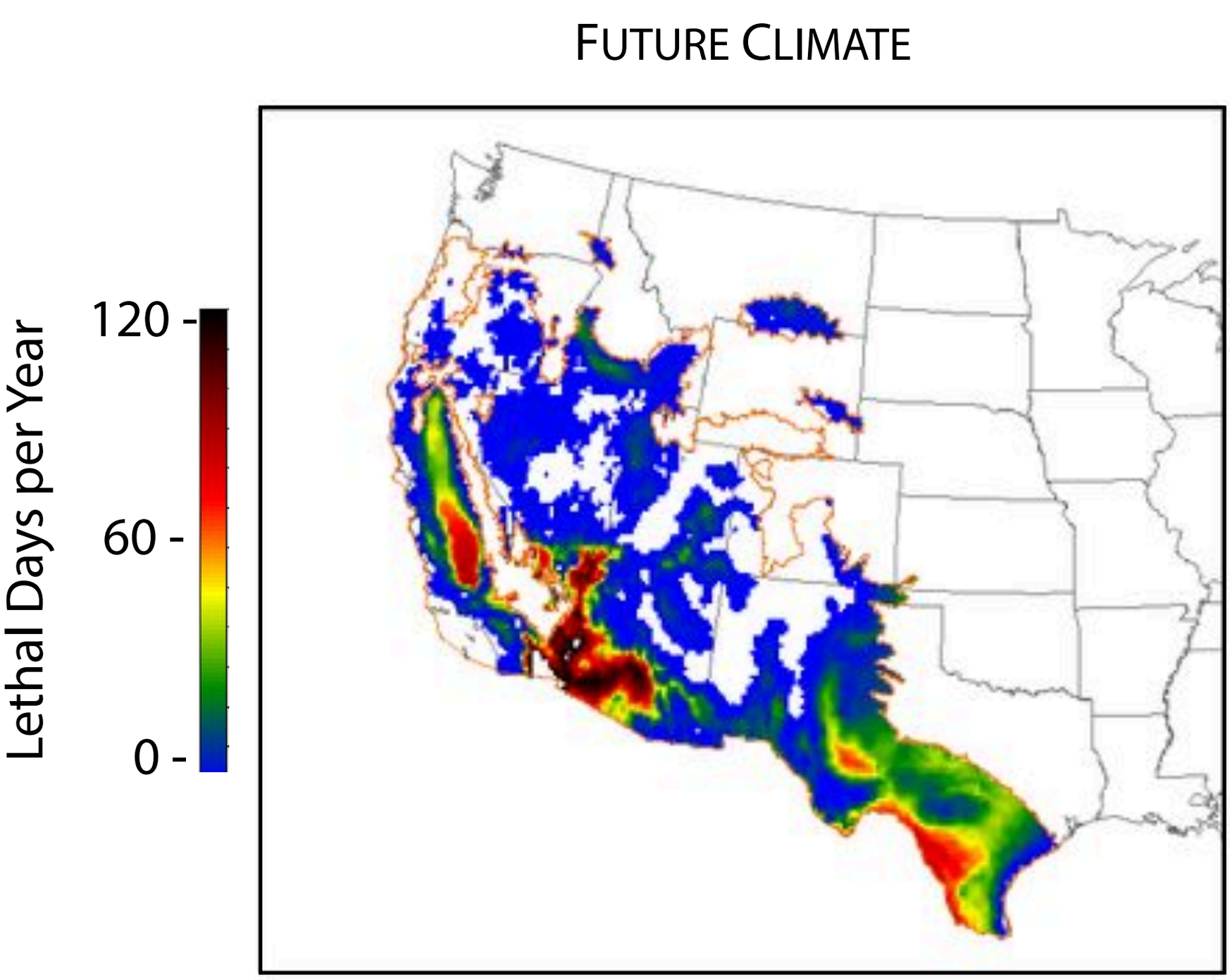
Climate change increases number of lethal dehydration days

CURRENT CLIMATE



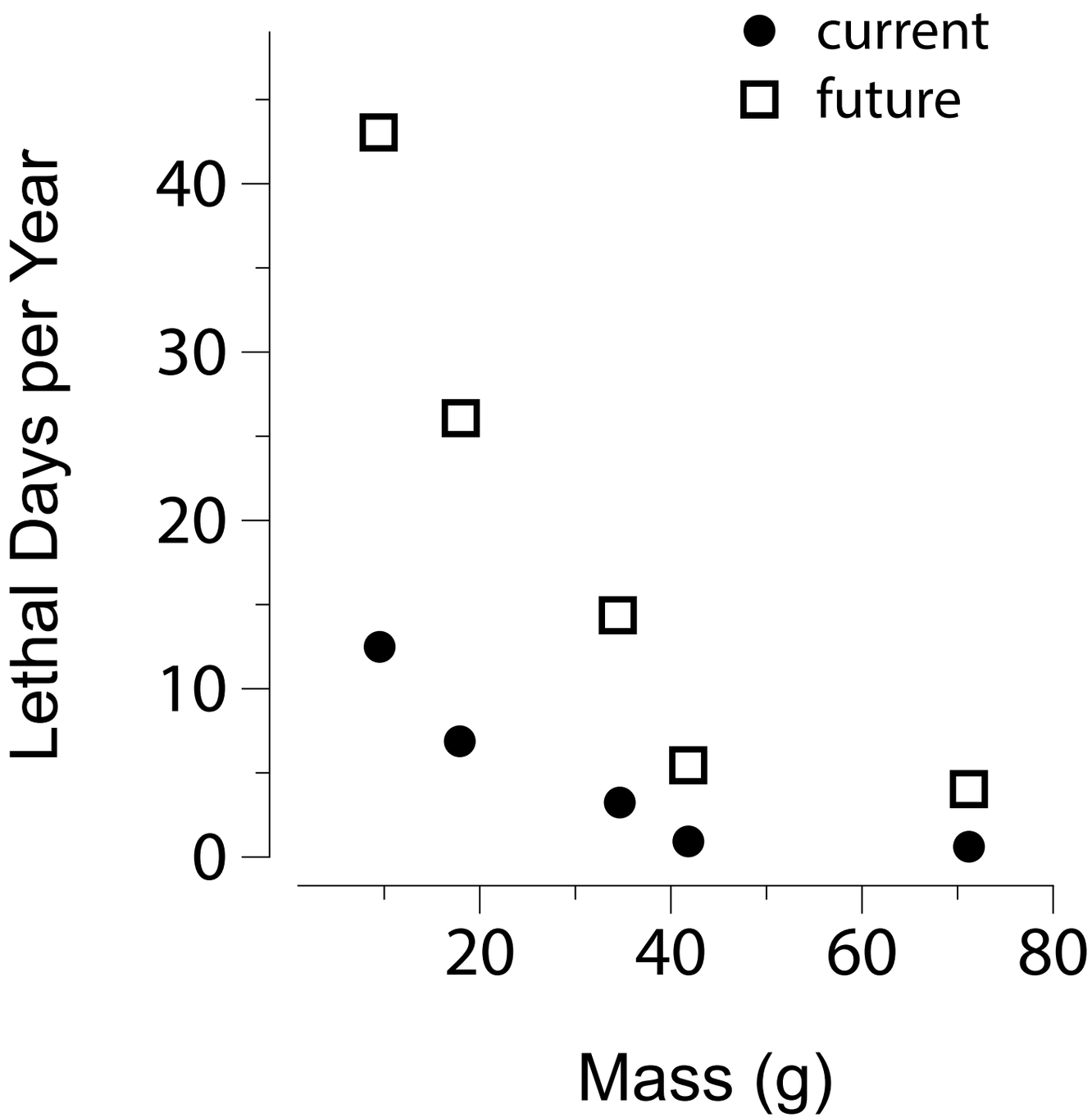
Albright et al. 2017

Climate change increases number of lethal dehydration days



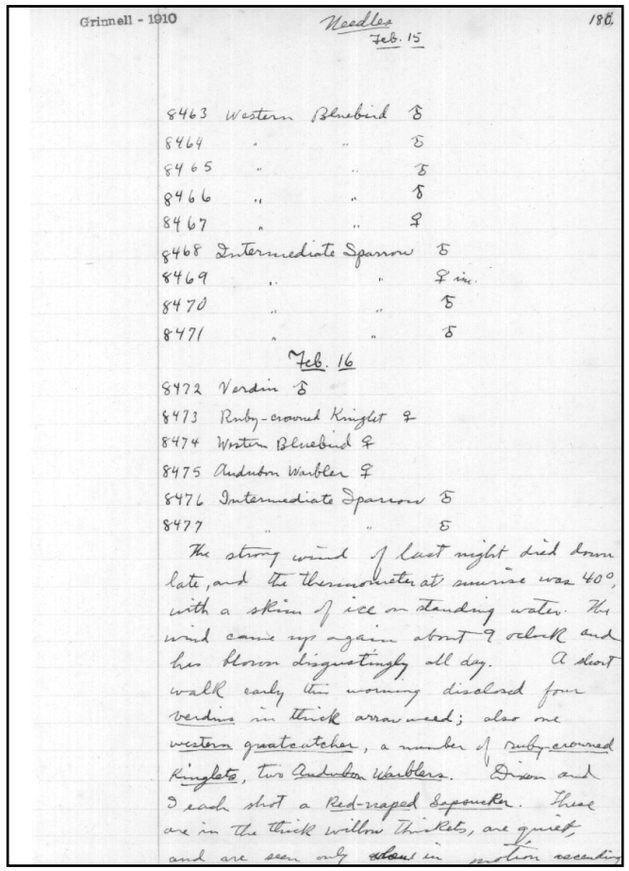
Albright et al. 2017

Small birds should be more vulnerable to warming than large birds



Albright et al. 2017

The Grinnell Resurvey Project: Leveraging 100 years of change



Grinnell - 1910 Needles 180

Feb. 15

8463 Western Bluebird ♂
8464 " " ♂
8465 " " ♂
8466 " " ♀
8467 " " ♀
8468 Intermediate Sparrow ♂
8469 " " ♀ im.
8470 " " ♂
8471 " " ♂

Feb. 16

8472 Verdin ♂
8473 Ruby-crowned Kinglet ♀
8474 Western Bluebird ♀
8475 Audubon Warbler ♀
8476 Intermediate Sparrow ♂
8477 " " ♂

The strong wind of last night died down late, and the thermometer at sunrise was 40°, with a skim of ice on standing water. The wind came up again about 9 o'clock and has blown disagreeingly all day. A short walk early this morning disclosed four verdins in thick arrowweed; also one western grnatcatcher, a number of ruby-crowned kinglets, two Audubon Warblers. Dixon and I each shot a Red-naped Sapsucker. These are in the thick willow thickets, are quiet, and are seen only [illegible] in motion ascending

The Grinnell Resurvey Project: Leveraging 100 years of change

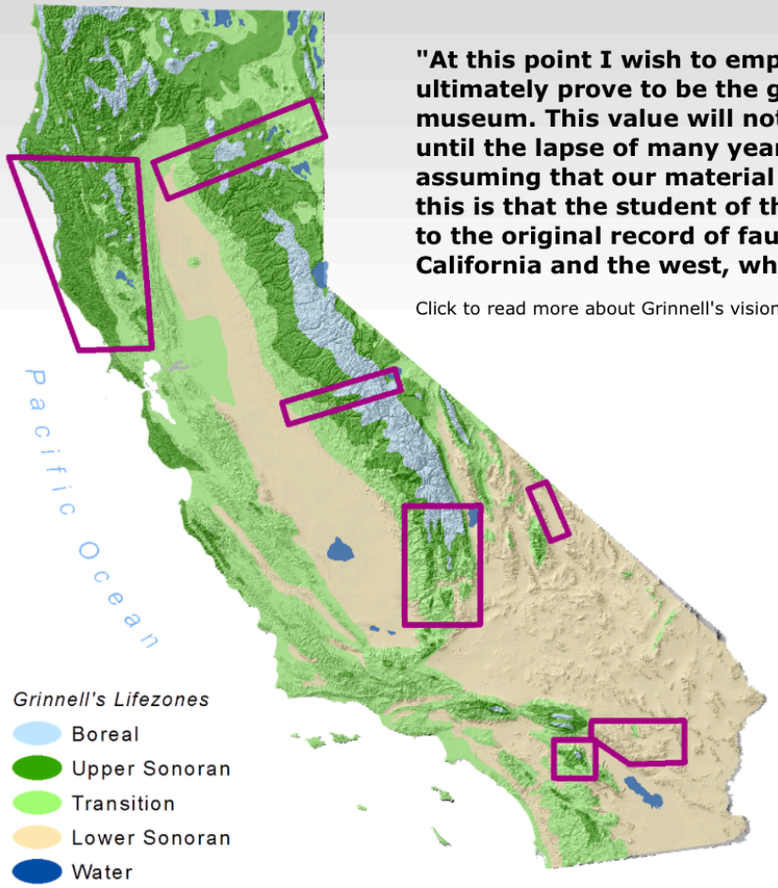
The Grinnell Resurvey Project

The Museum of Vertebrate Zoology, UC Berkeley

Home | Current Research | Resurvey Locations | People Involved | Refugia | Pubs and Products | News

Recent News

Resurveys of birds in California's Central Valley initiated in summer 2015.



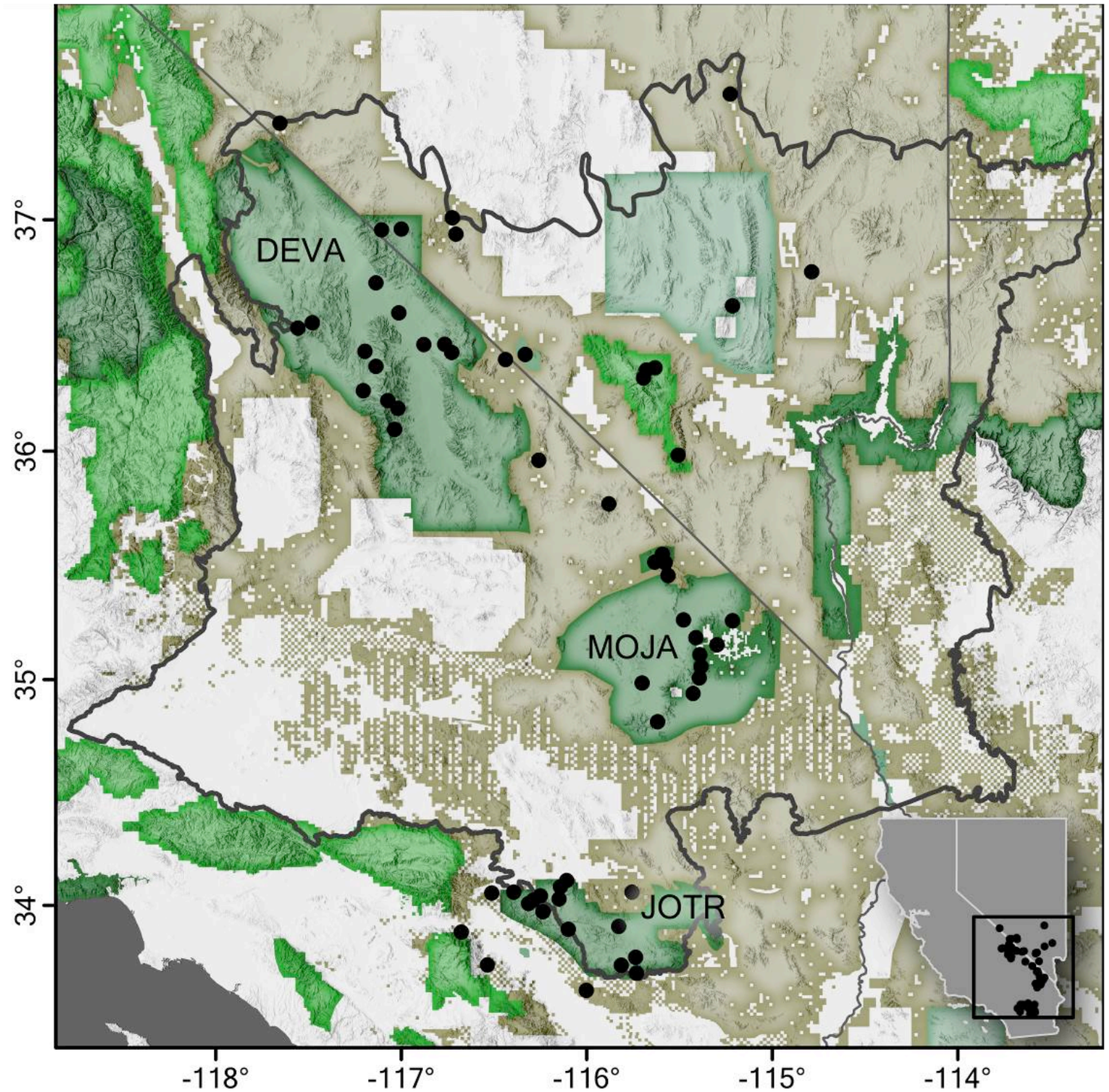
"At this point I wish to emphasize what I believe will ultimately prove to be the greatest value of our museum. This value will not, however, be realized until the lapse of many years, possibly a century, assuming that our material is safely preserved. And this is that the student of the future will have access to the original record of faunal conditions in California and the west, wherever we now work."

Click to read more about Grinnell's vision

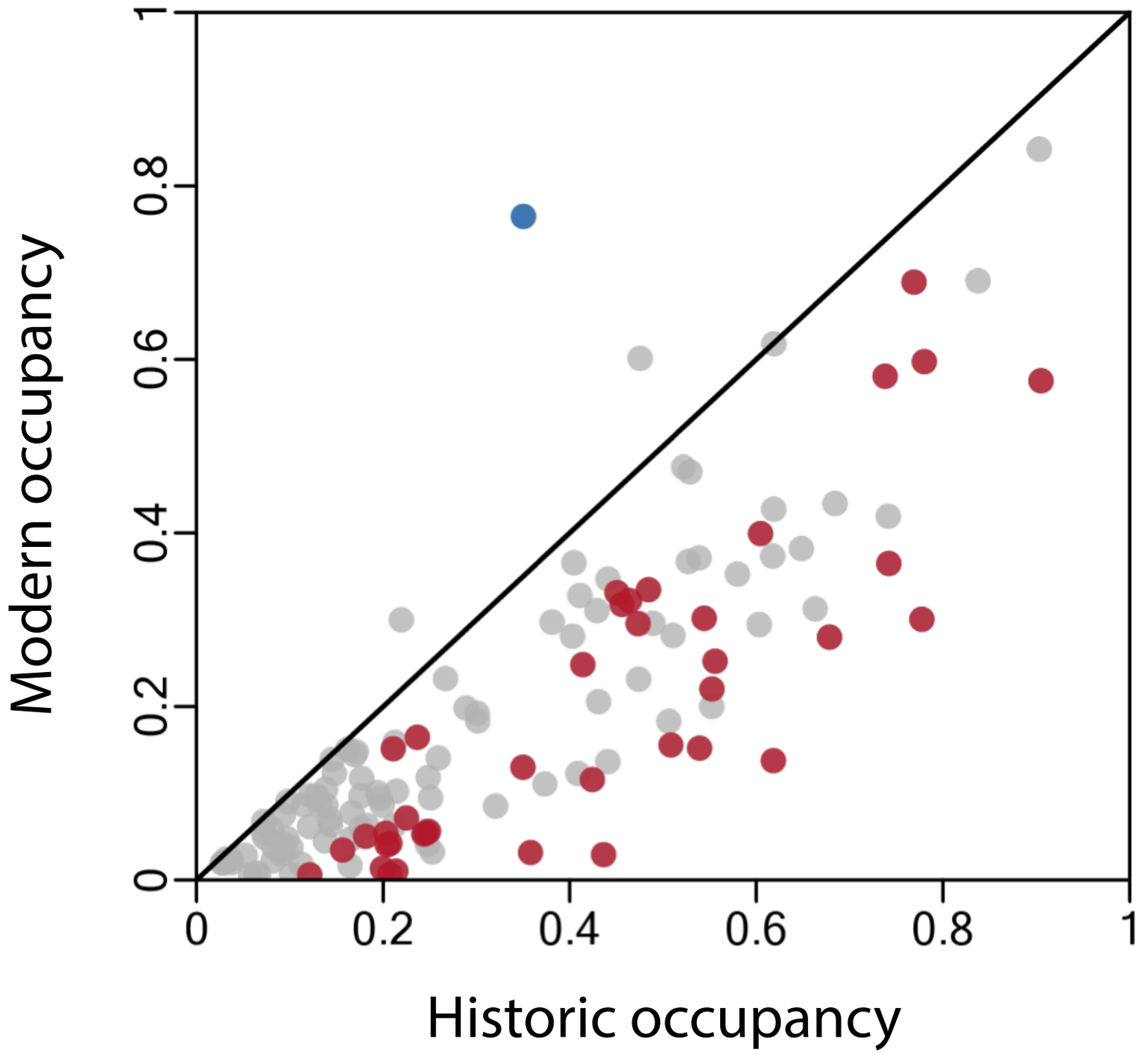
Joseph Grinnell, 1910
"The Uses and Methods of a Research Museum"
Popular Science Monthly

Resurvey Before and After Photos

Deserts are physiologically stressful but have minimal human impacts



Most birds declined over the last 100 years



Iknayan *et al.*, *In review*

Wide range of species that have declined over the last 100 years

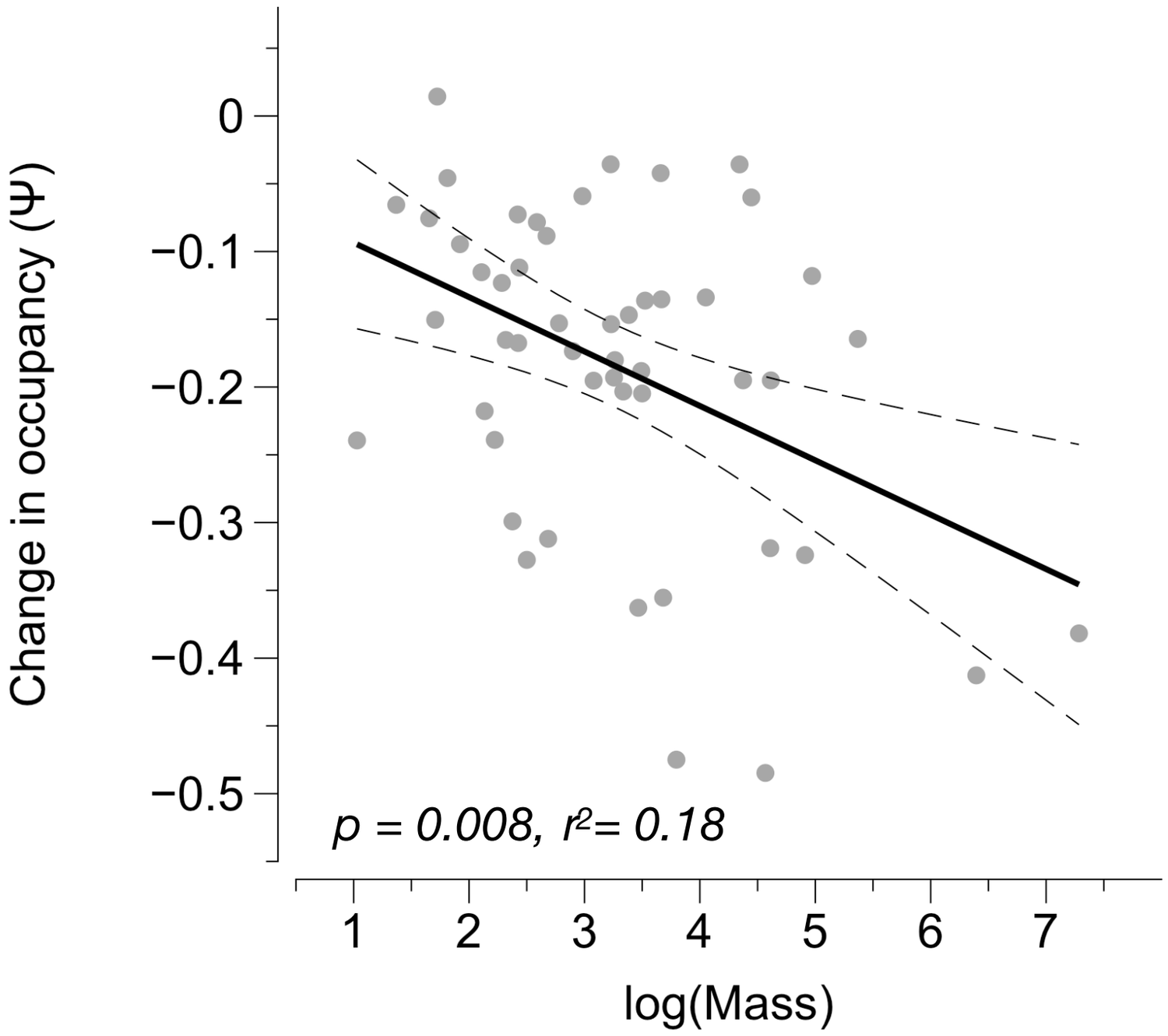




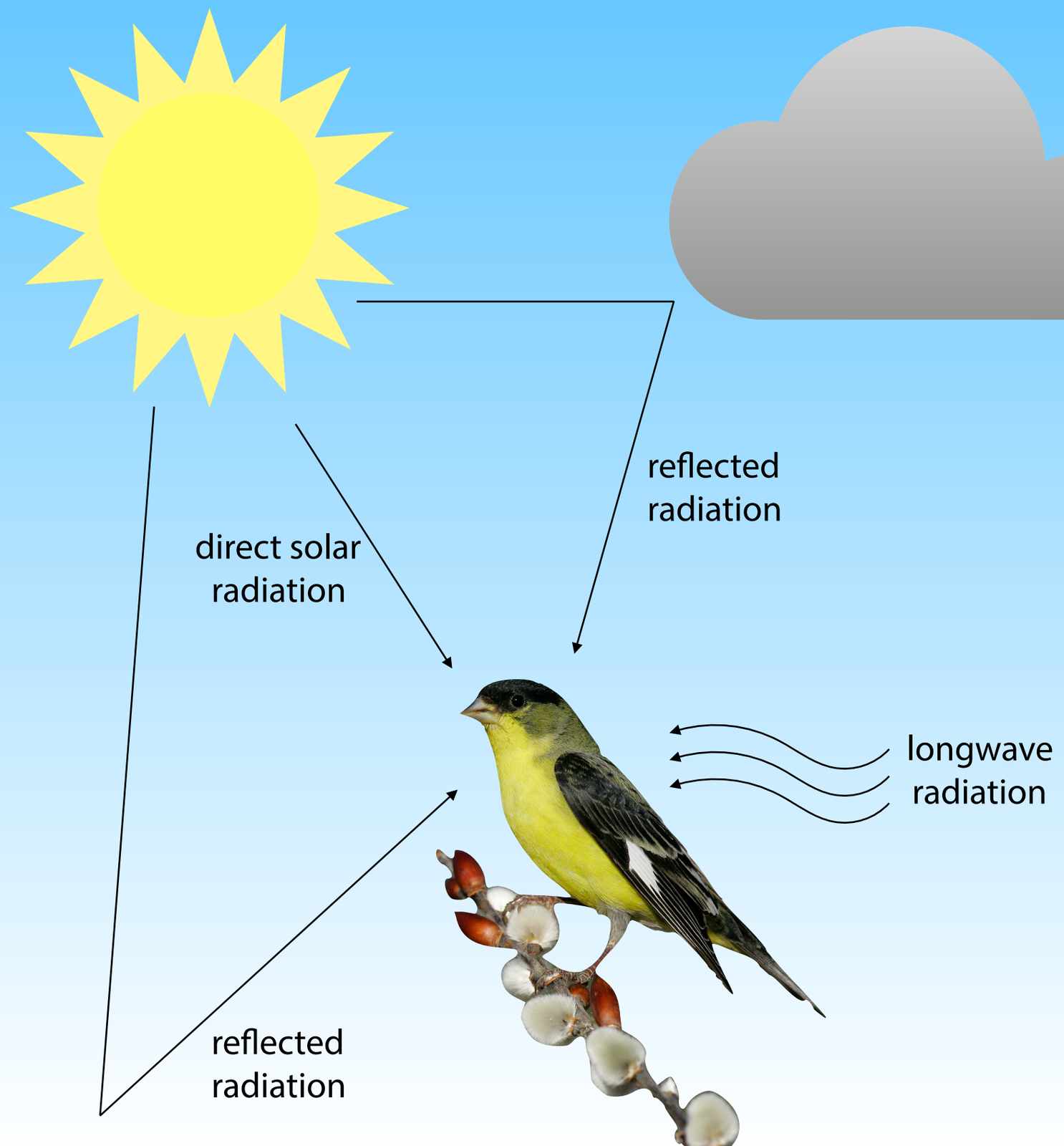




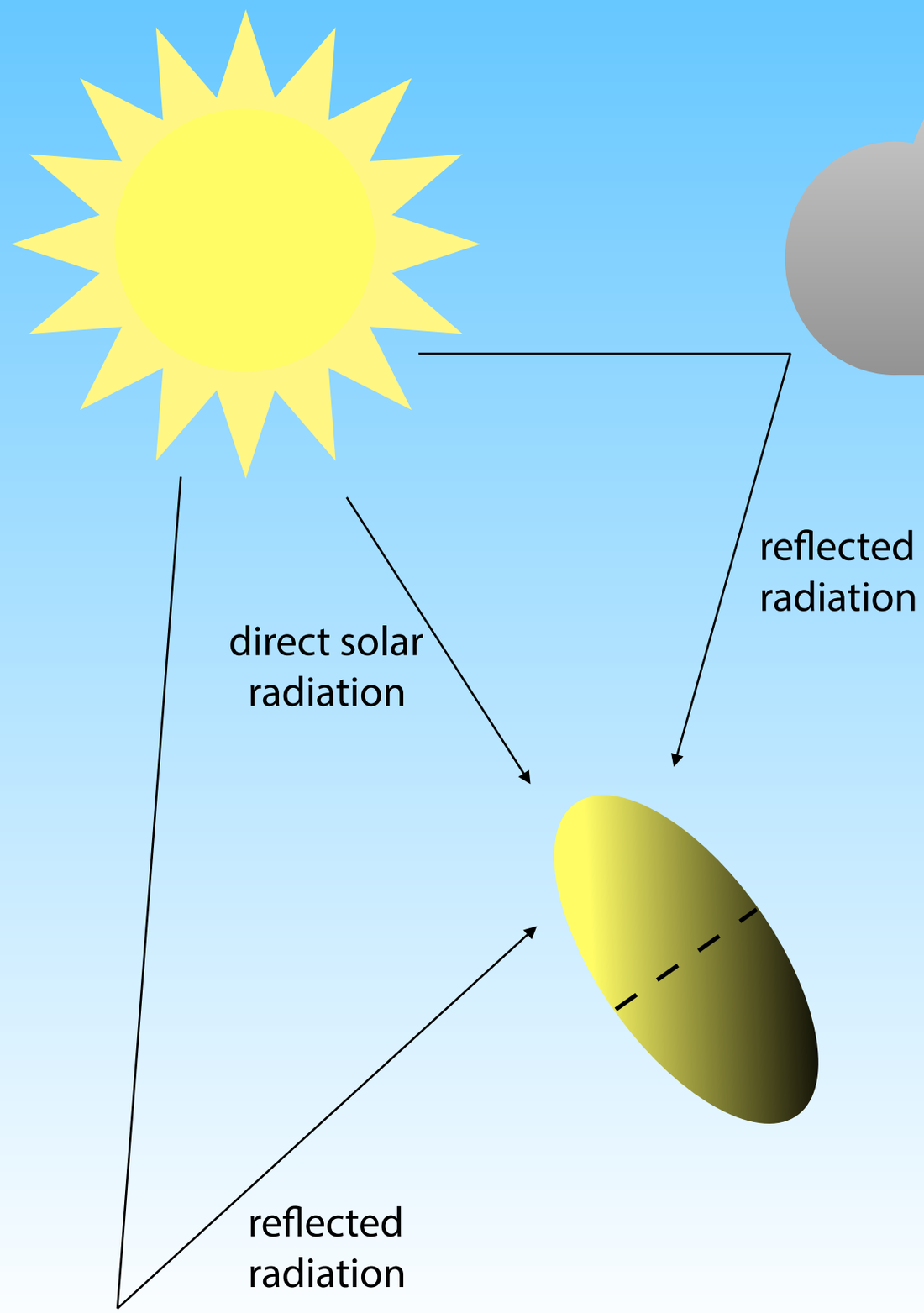
The decline is related to mass, but in the opposite direction as expected



Sources of heat flux from the perspective of a bird



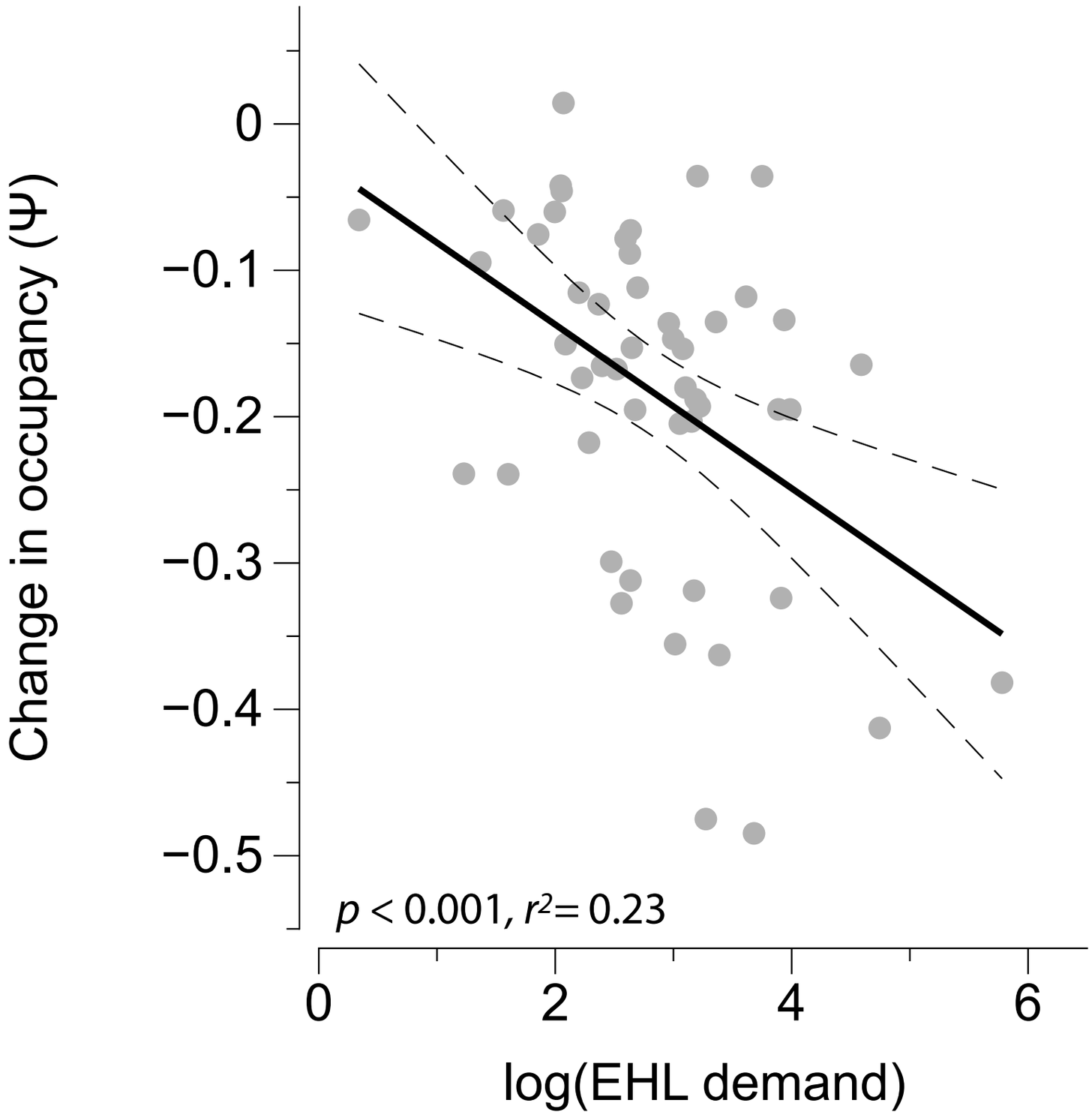
Assign biophysical properties



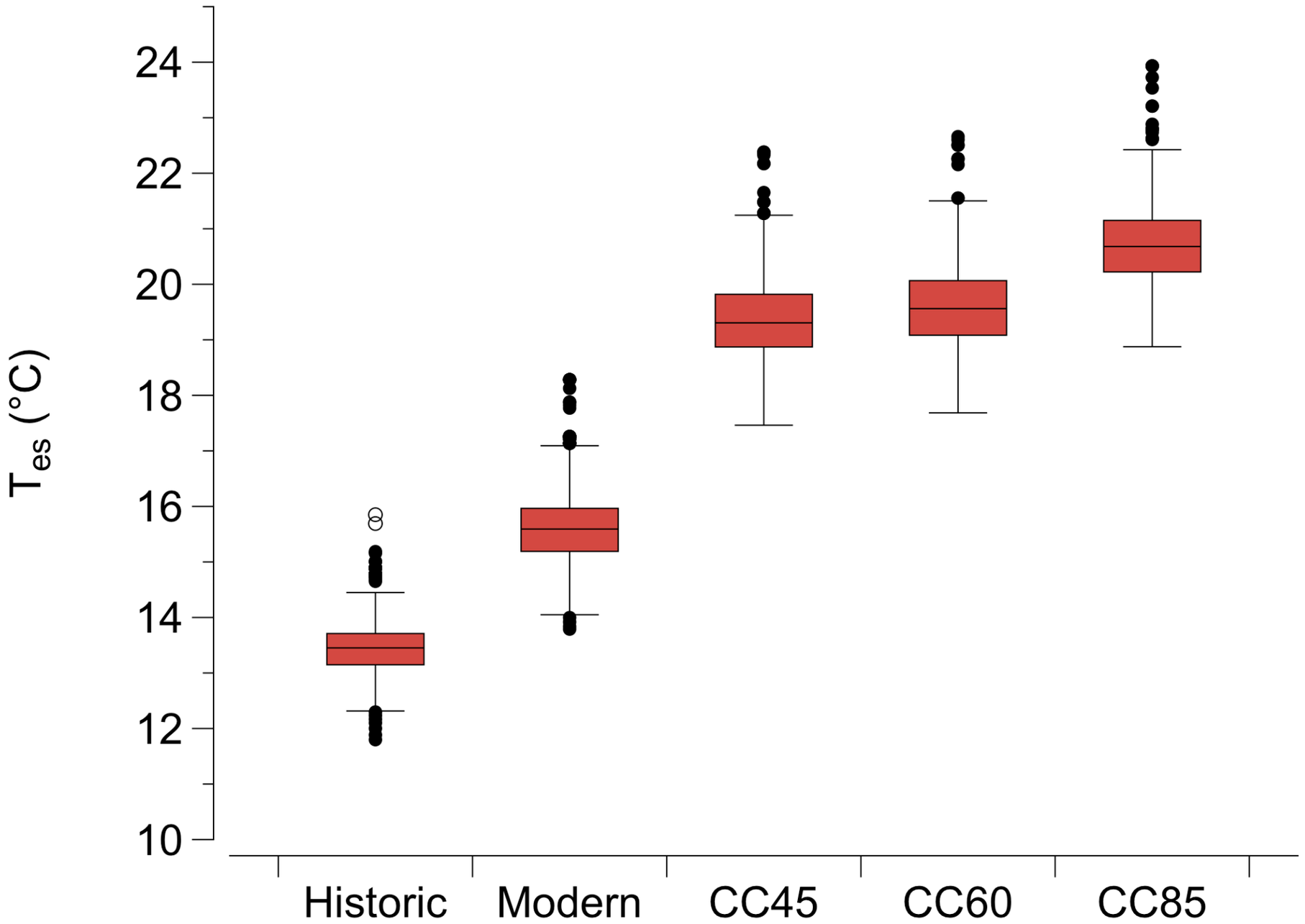
biophysical traits

mass
feather length
barbule density
insulation depth
length
width
height
feather absorptance

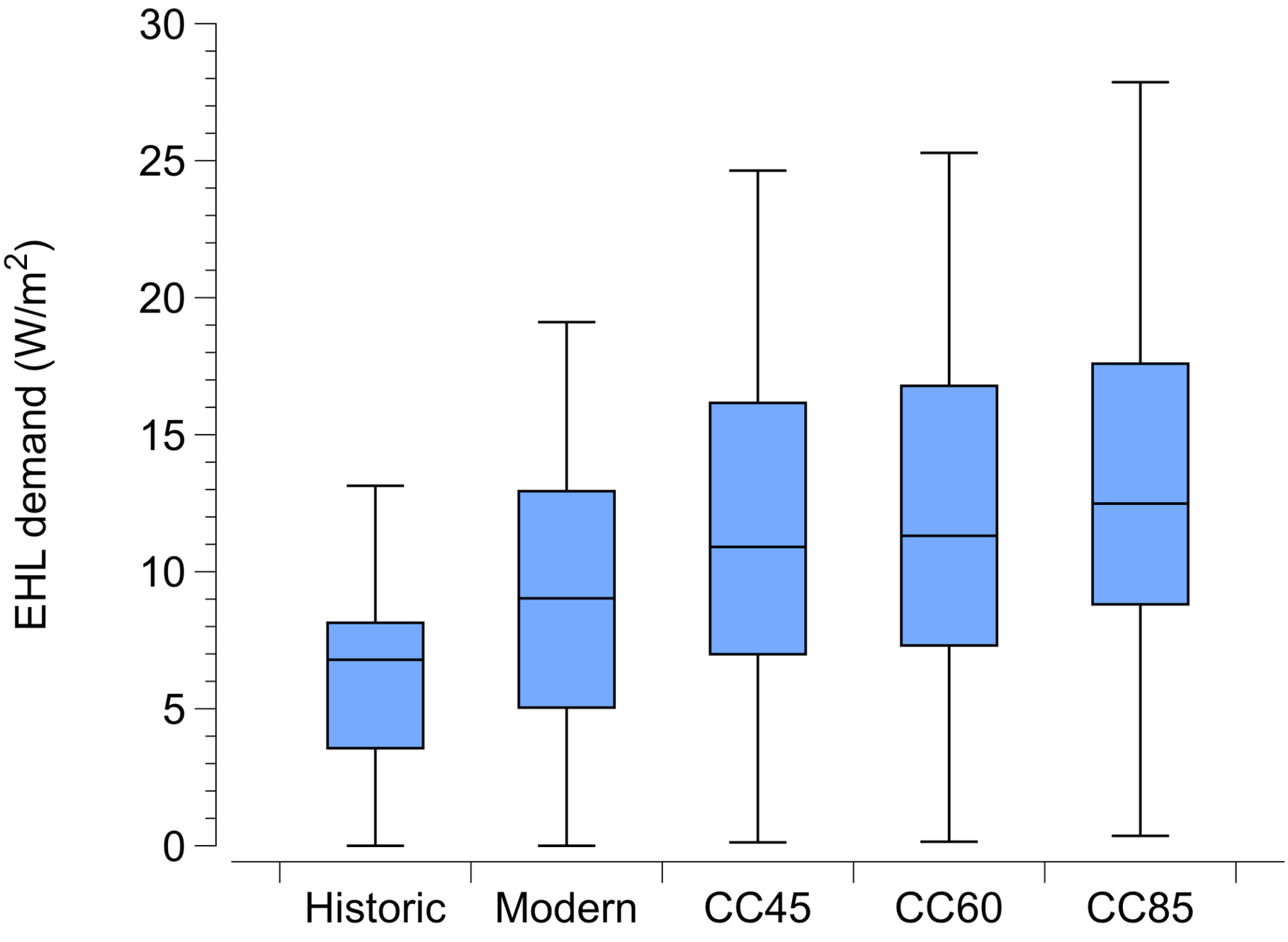
Bird decline related to evaporative cooling demand



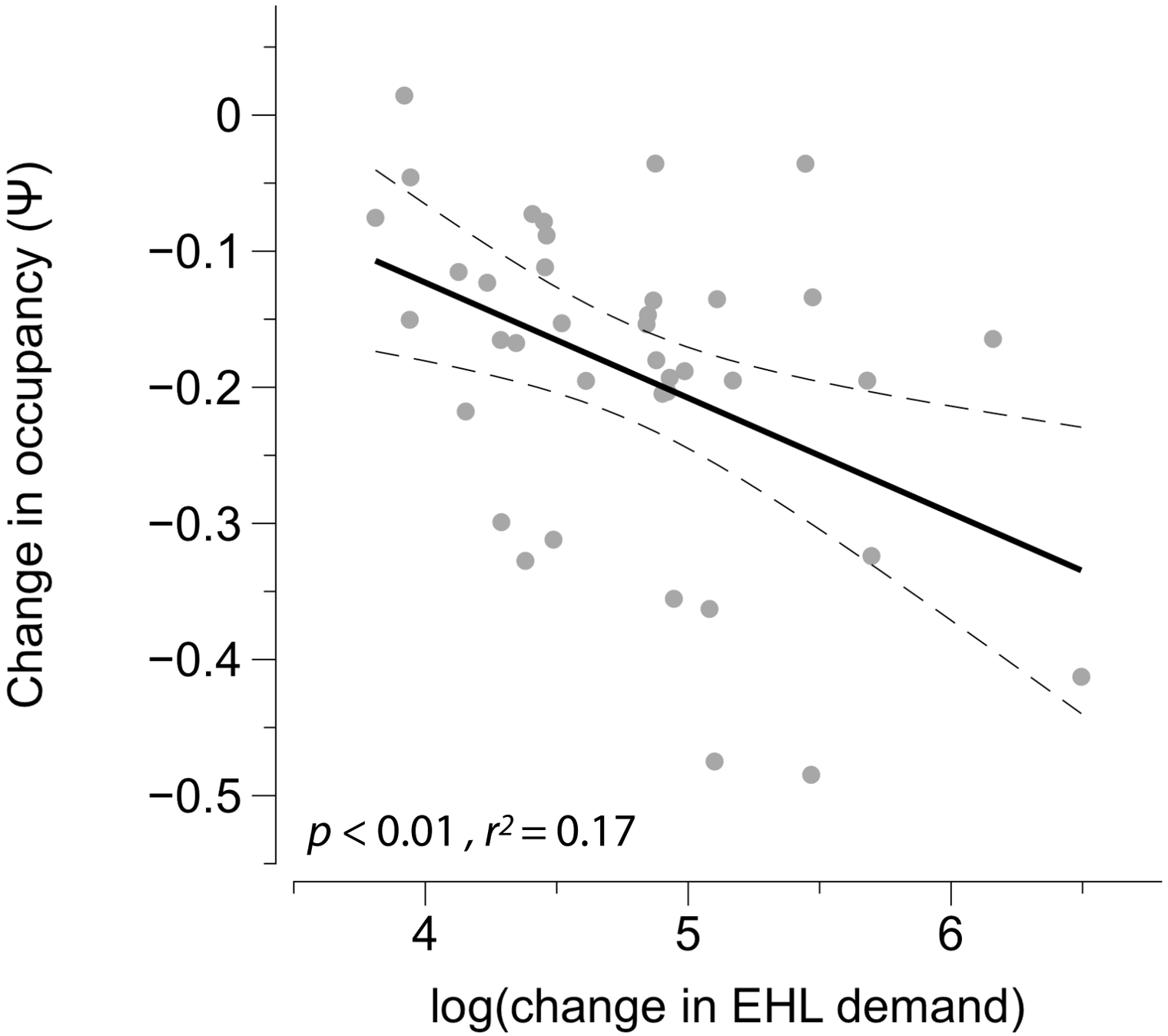
Bird decline related to evaporative cooling demand



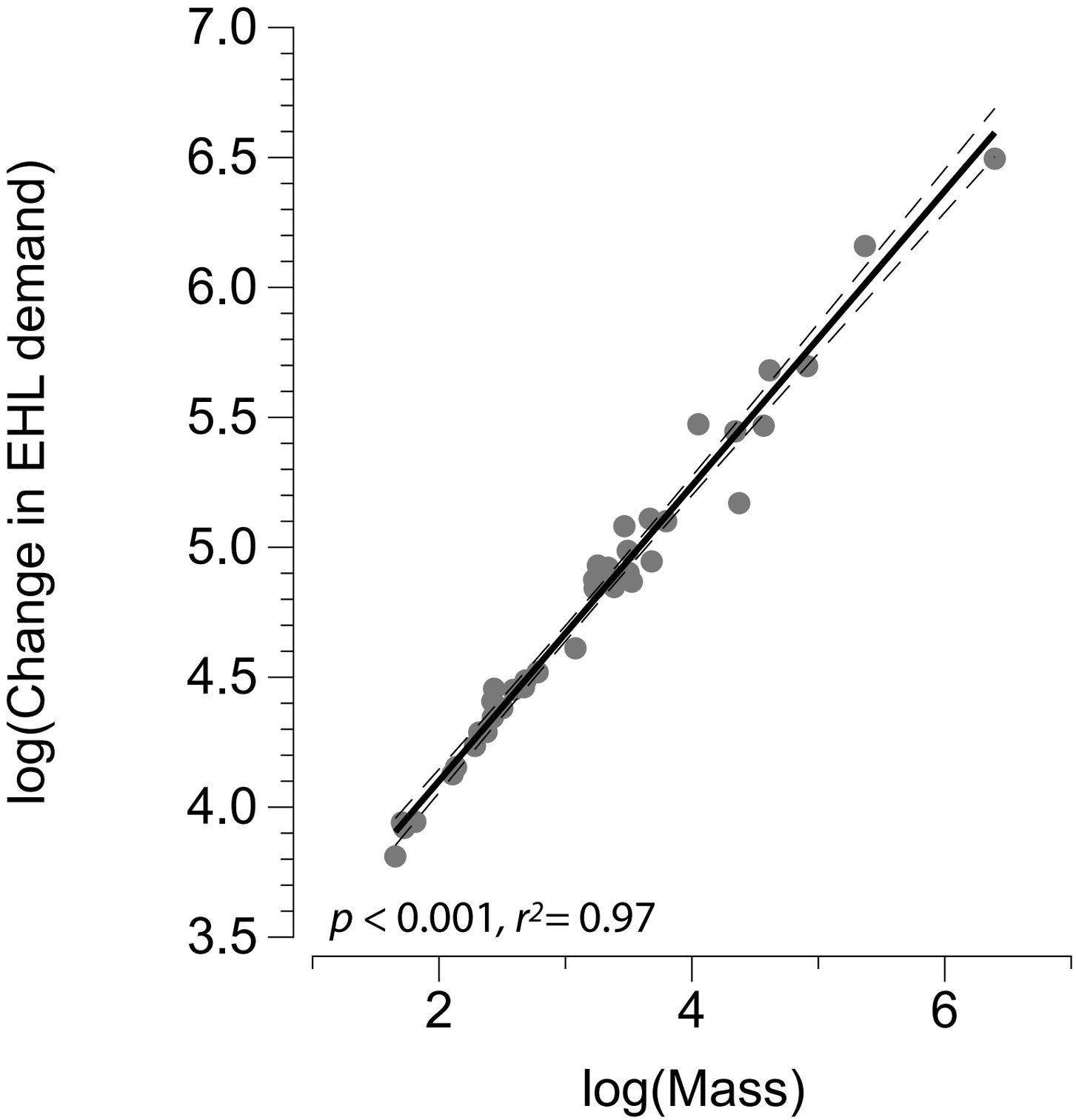
Bird decline related to evaporative cooling demand



Bird decline related to evaporative cooling demand

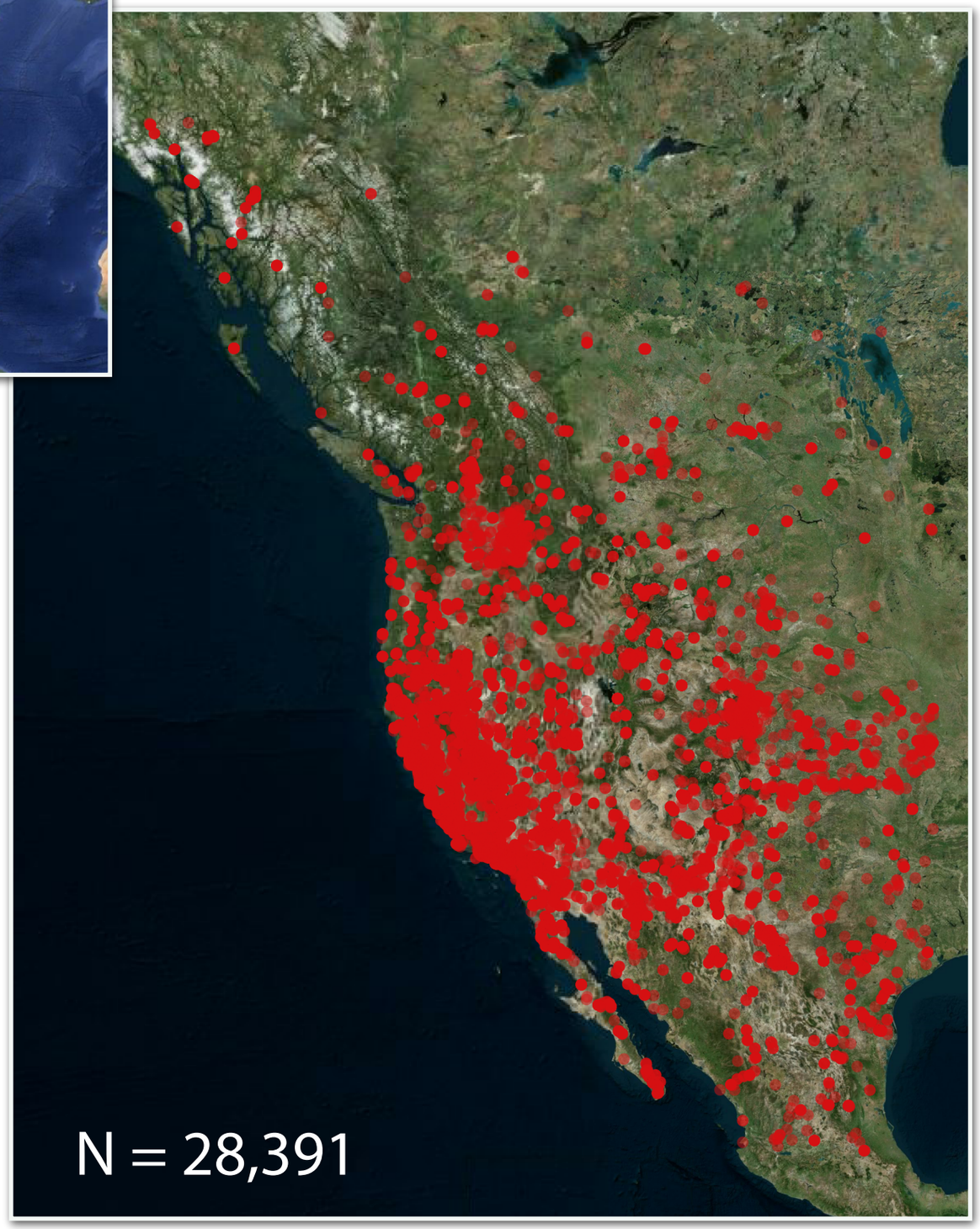


Bird decline related to evaporative cooling demand

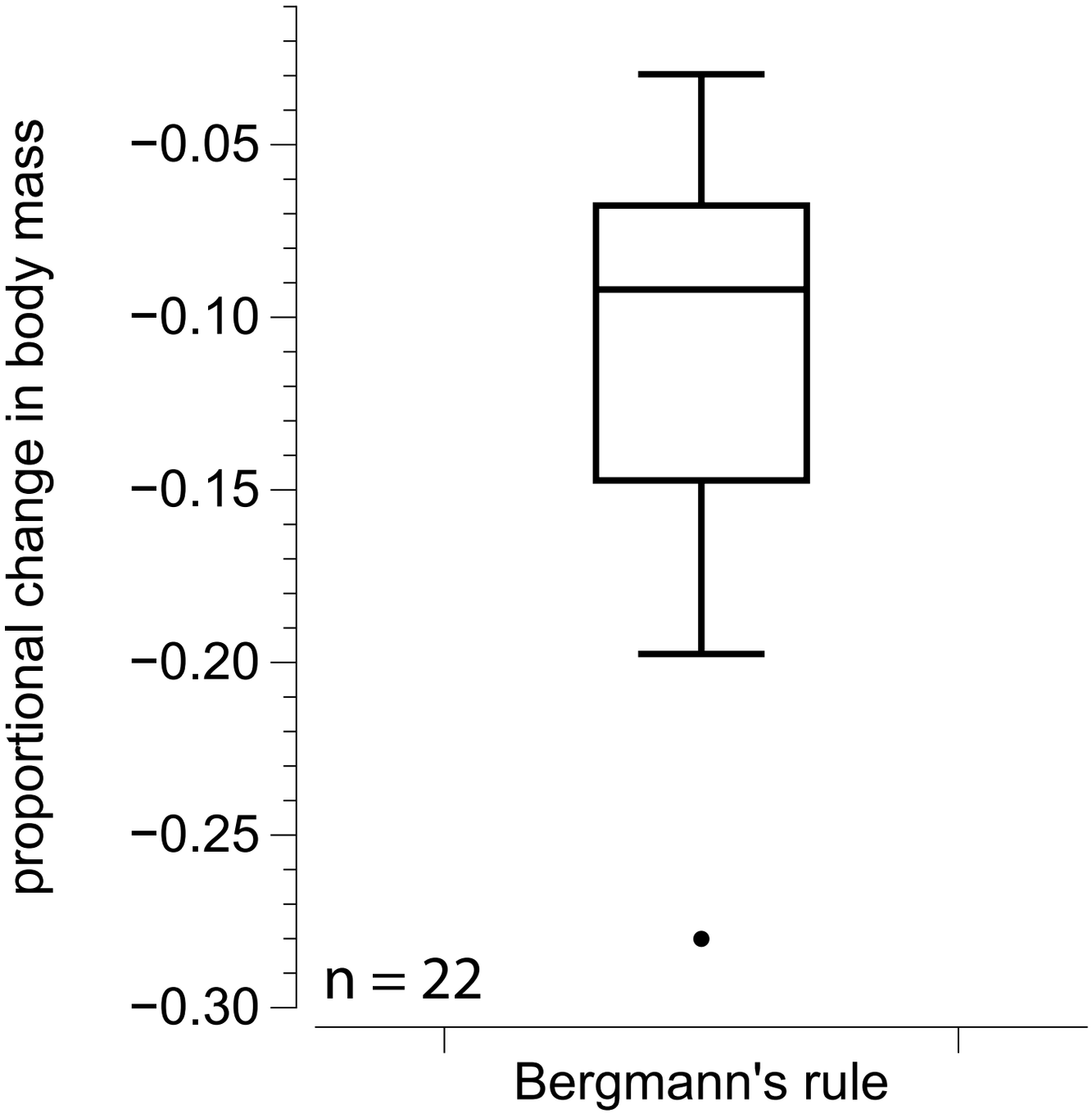


Bergmann's rule: Intra- and interspecific latitudinal variation in body size

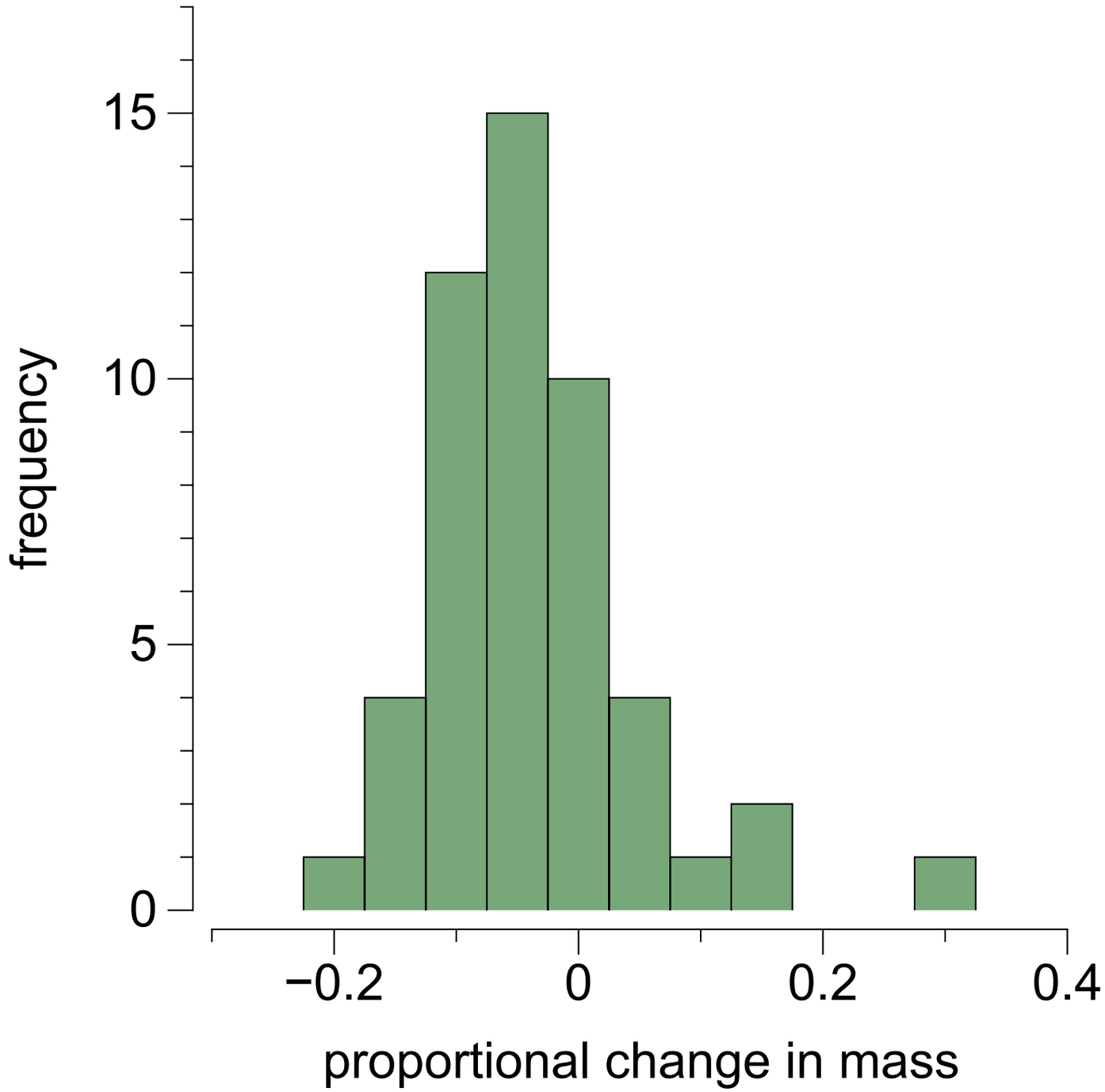
Intraspecific latitudinal variation in body size



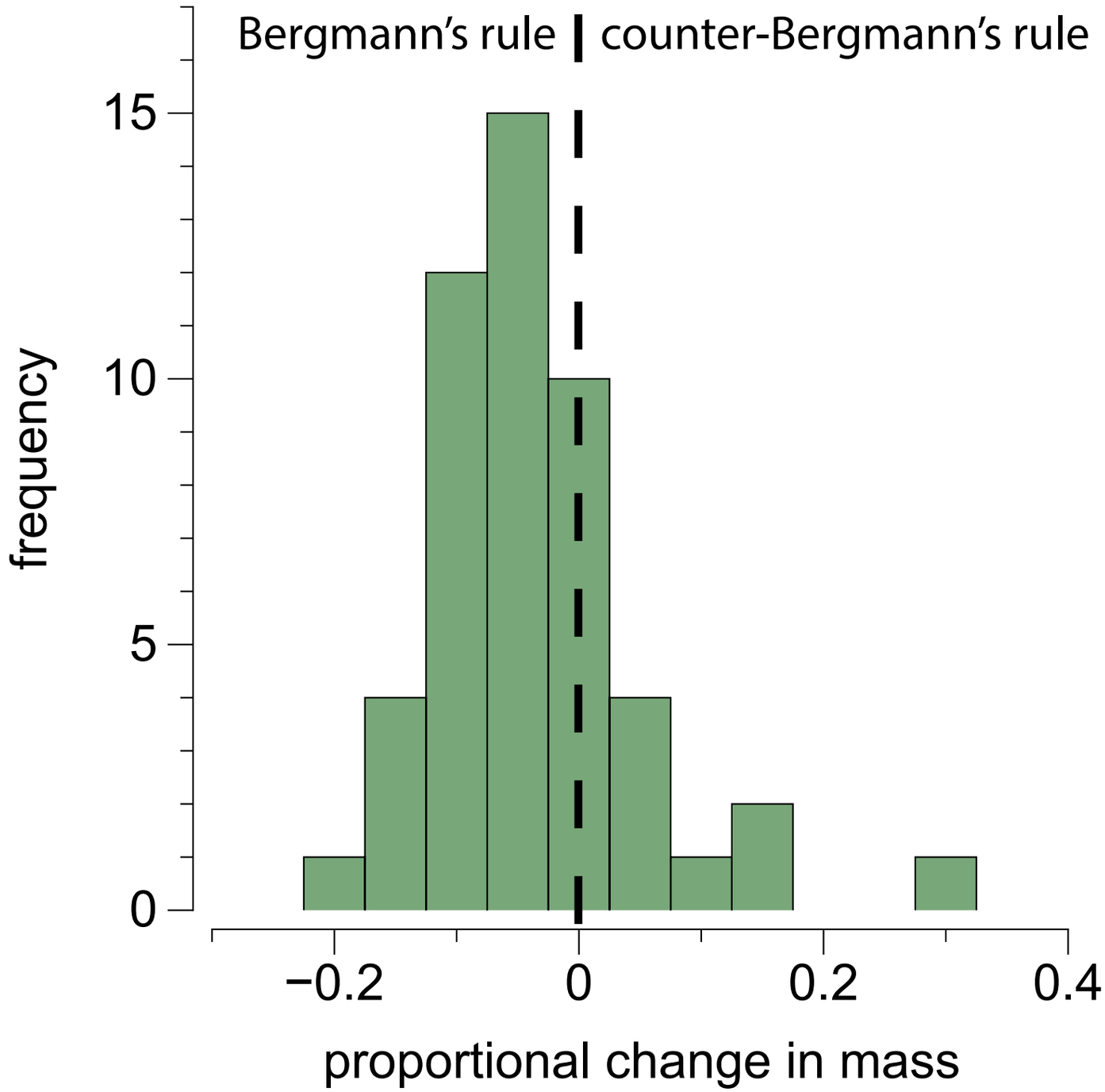
Bergmann's rule: Intra- and interspecific latitudinal variation in body size



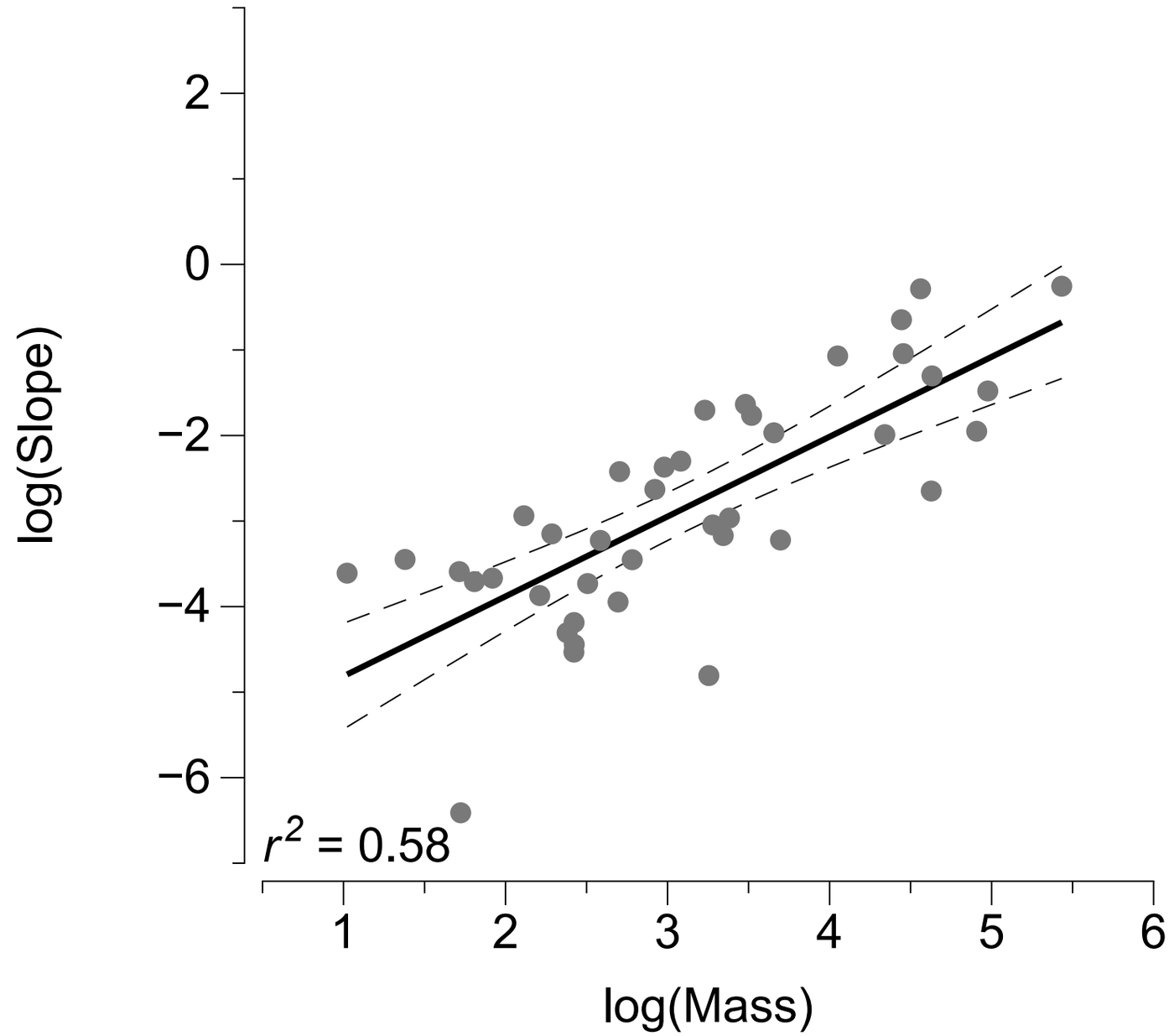
Variation in body size is ecologically-relevant for many species

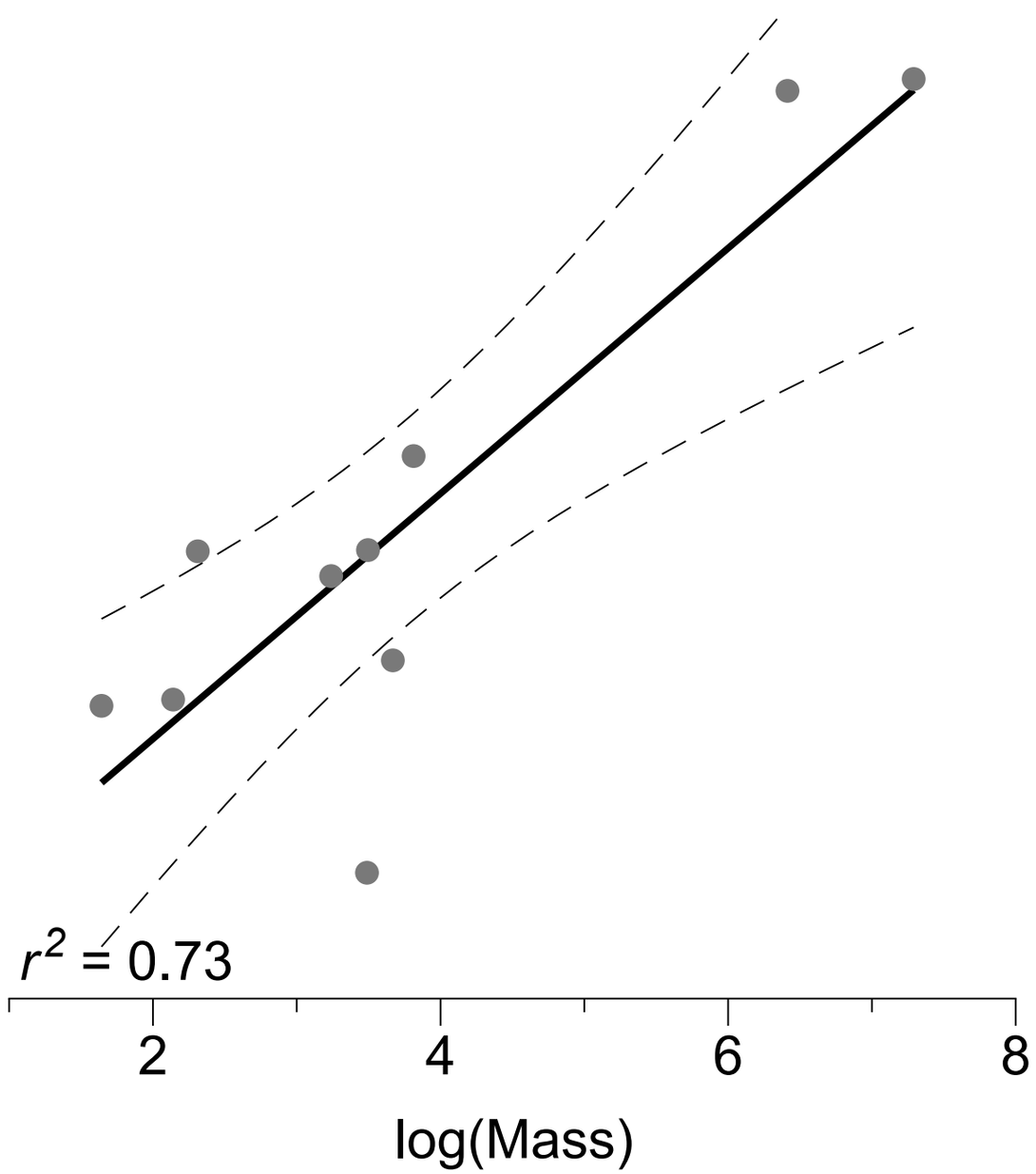


Variation in body size is ecologically-relevant for many species

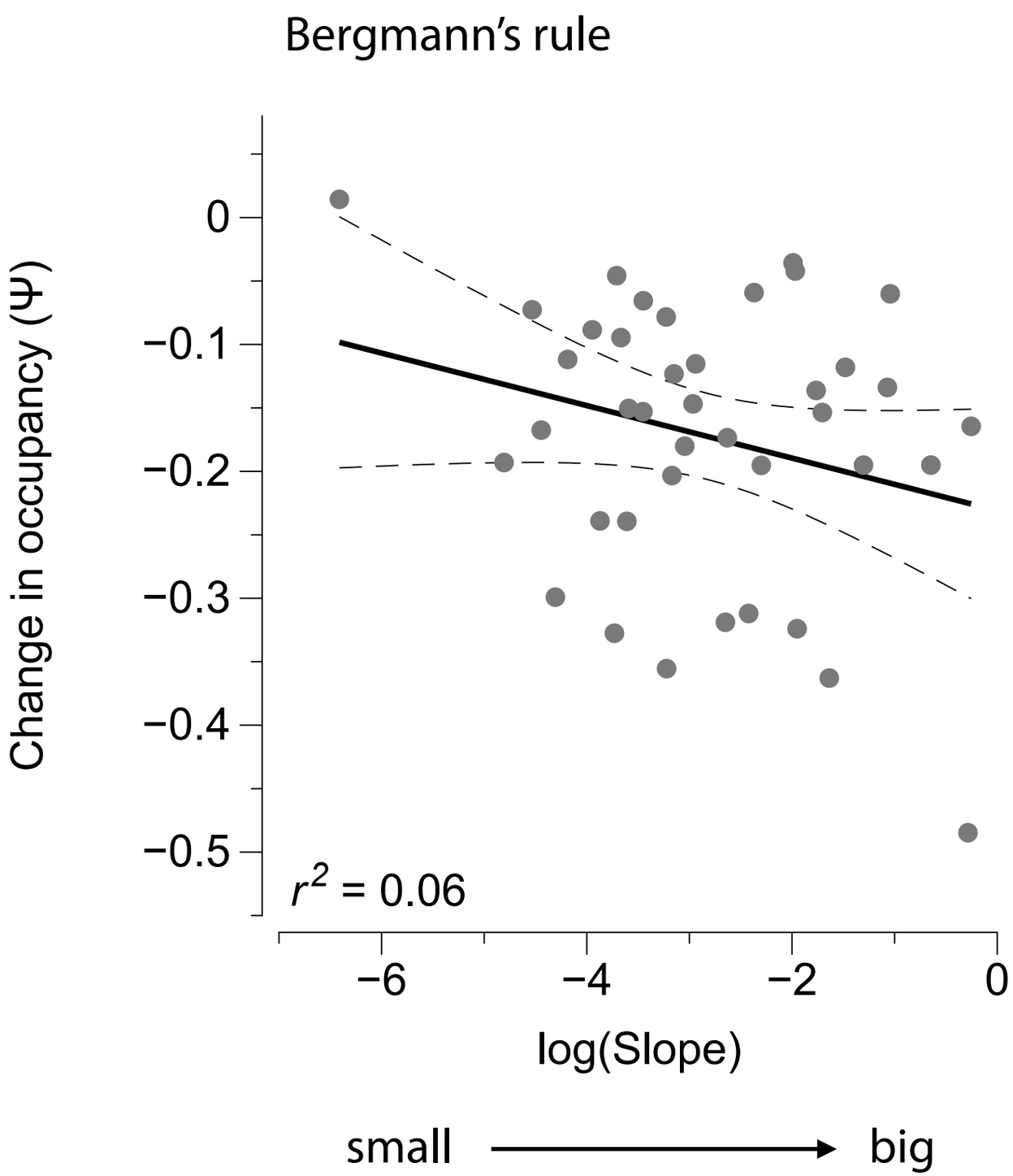


Large individuals tend to exhibit stronger effects consistent with Bergmann's rule

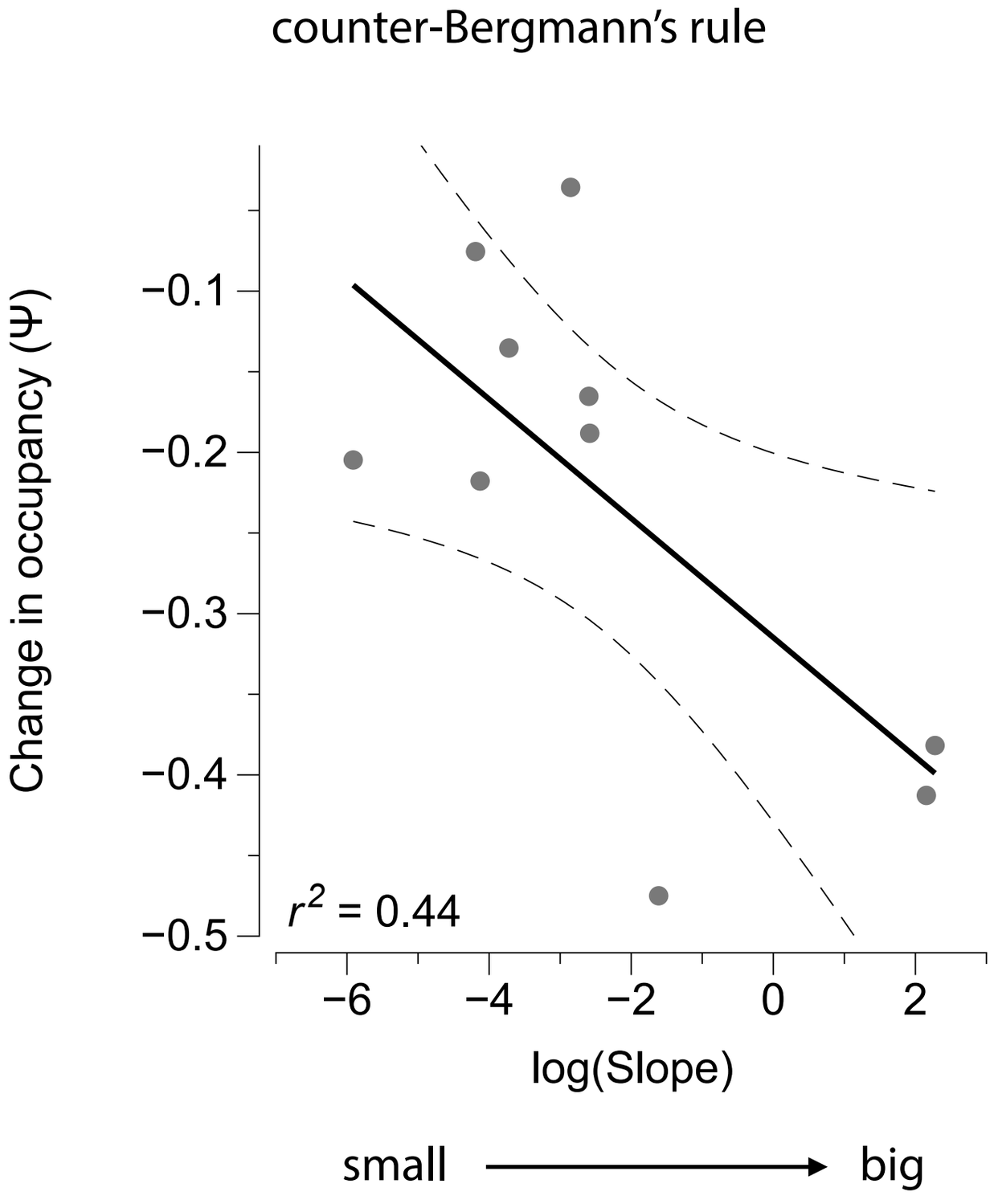




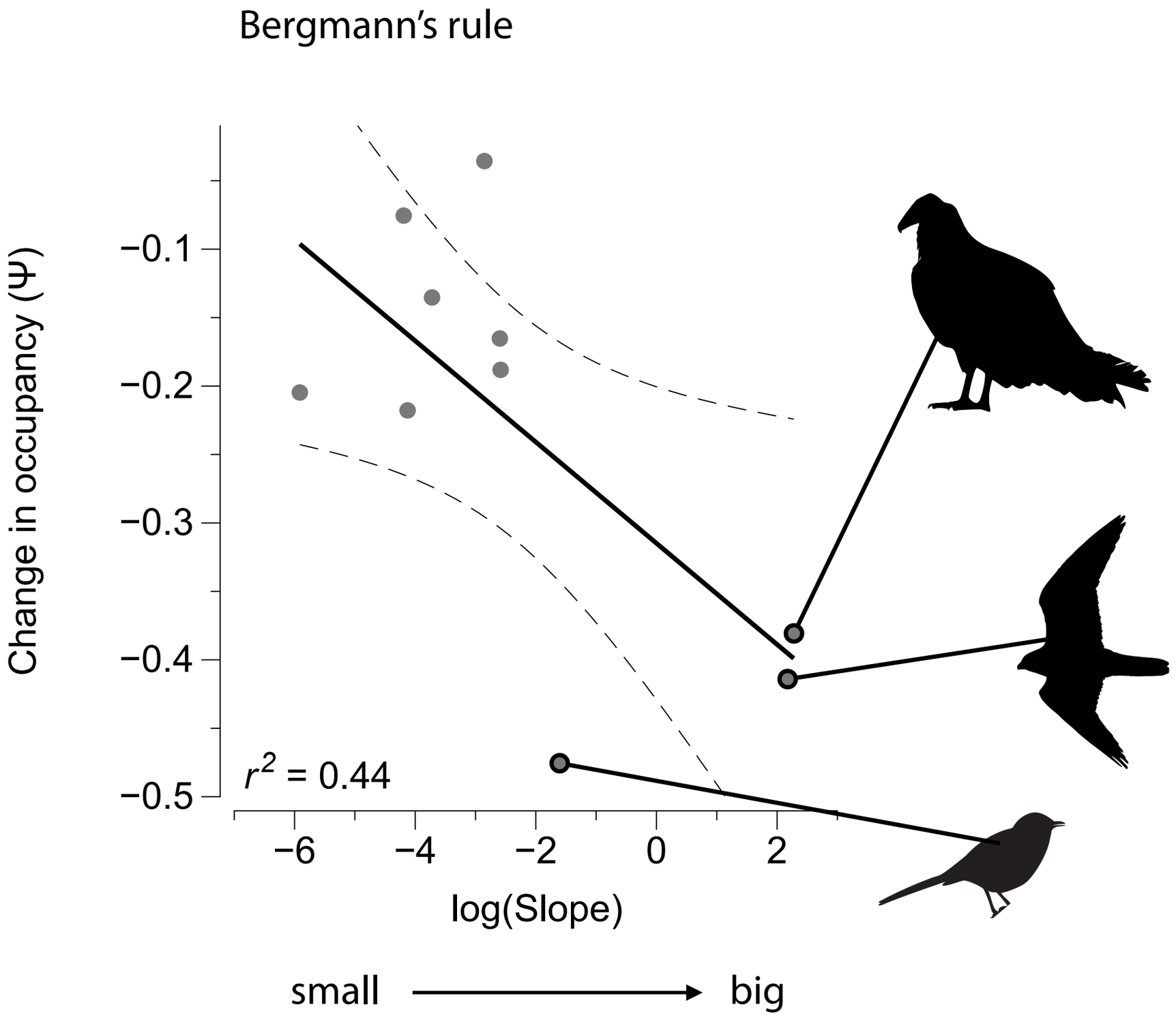
Species that follow Bergmann's rule exhibit similar levels of decline



Don’t break Bergmann’s rule if you’re big



Species that follow Bergmann's rule exhibit similar levels of decline



Summary

The collapse of desert bird communities appears to be related to the ineffectiveness of larger birds to efficiently cool

Bigger birds appear to be more influenced by warming than smaller birds

Intraspecific variation in body size appears to influence interspecific vulnerability to climate change

Acknowledgements

Carla Cicero

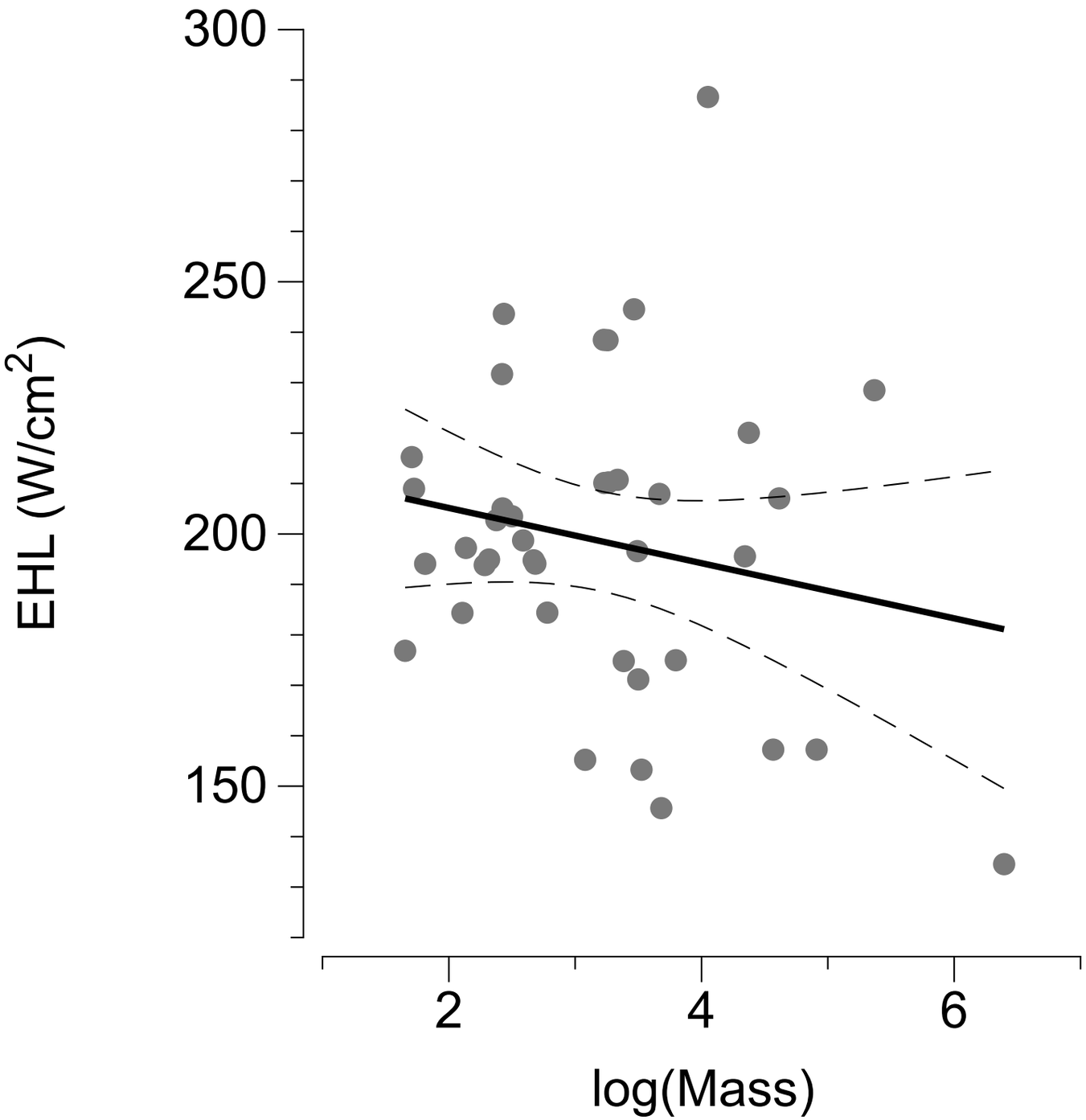
Rauri Bowie

Chris Conroy

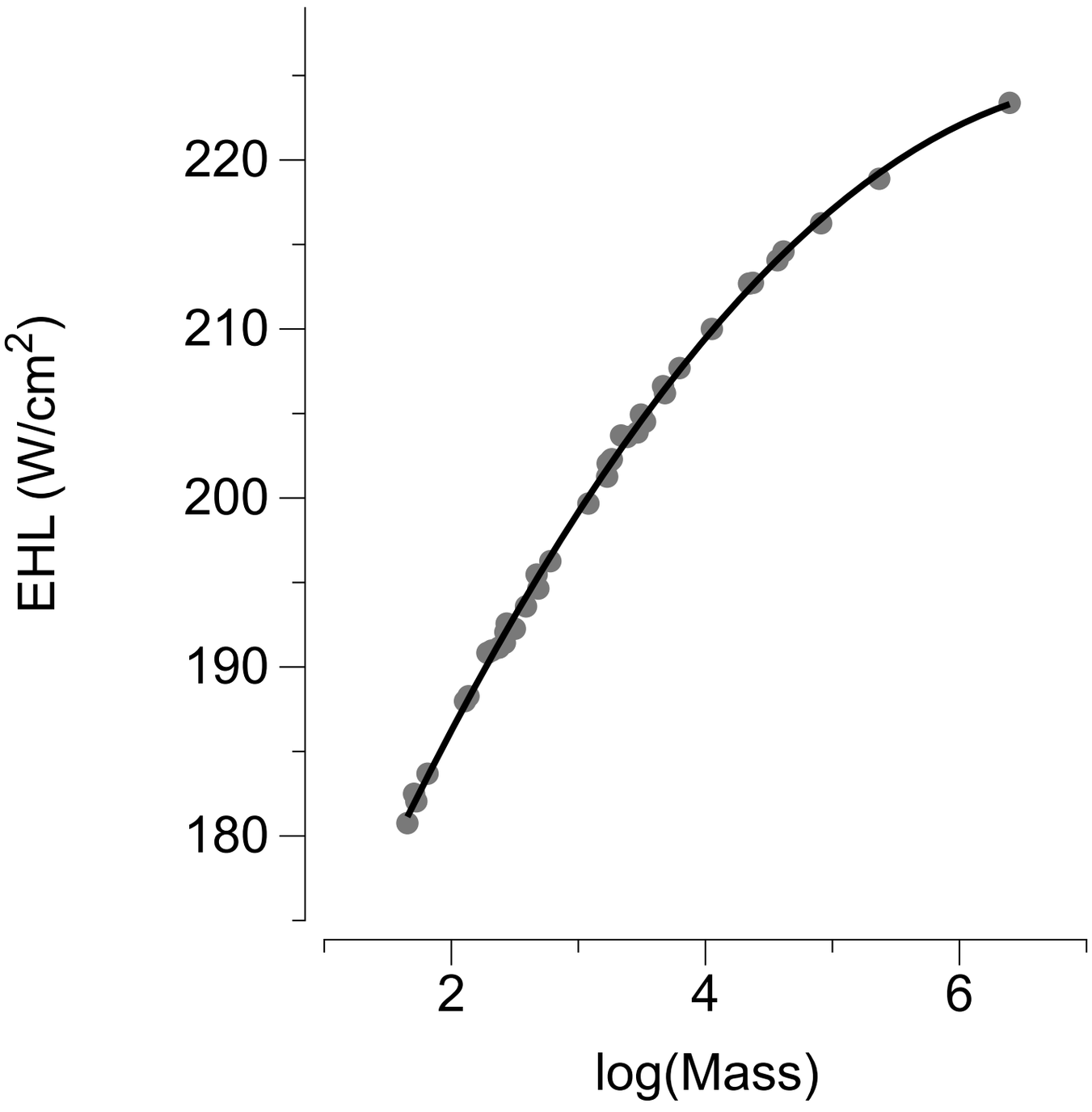
Carol Spencer

Steve Beissinger
Blair Wolf
Kell Iknayan
Sean Peterson
Nathan Van Schmidt
Tierne Nickel
Lelena Avila

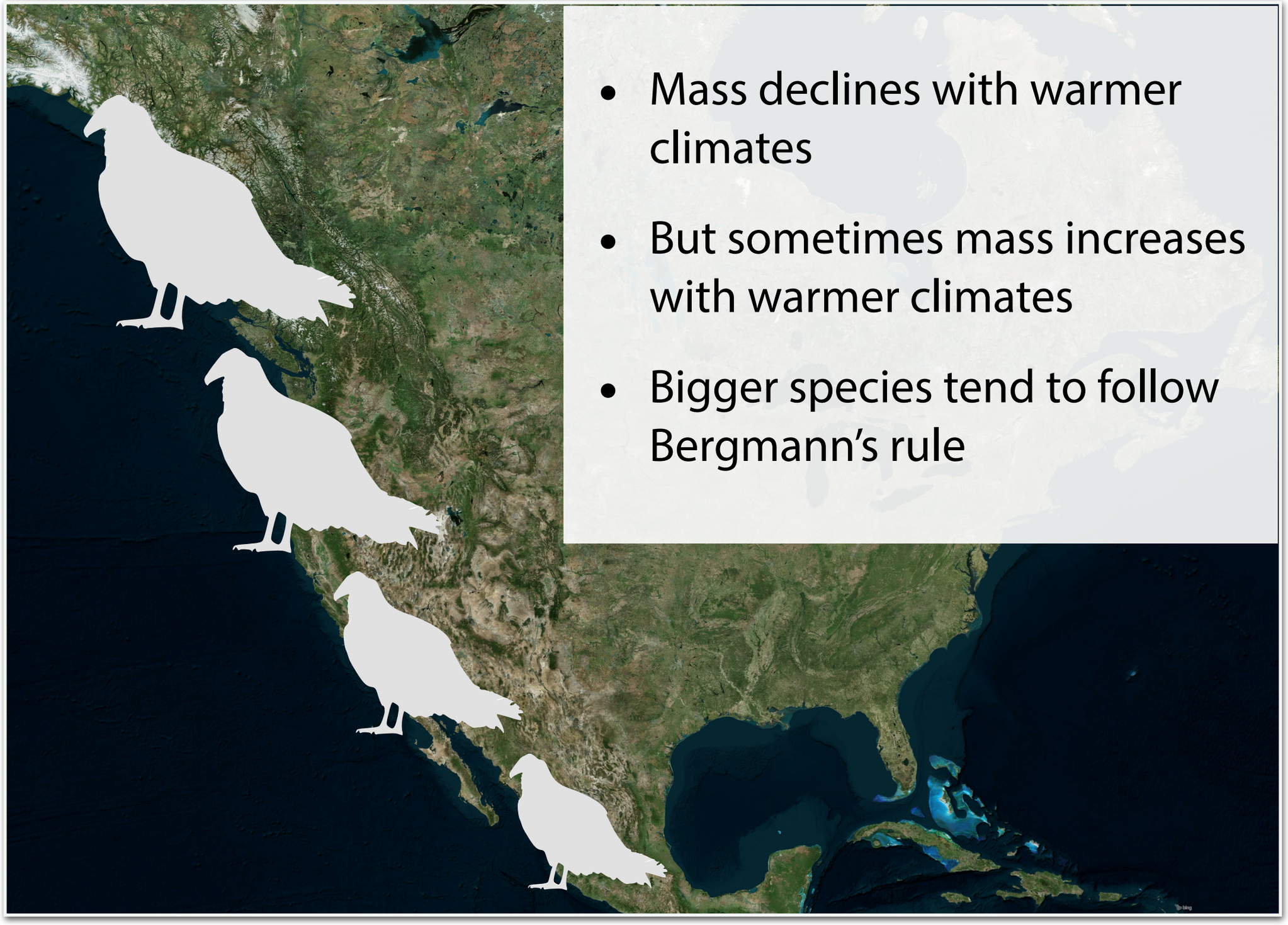
Bergmann's rule: an absolute mechanism - not a relative mechanism



Bergmann's rule: an absolute mechanism - not a relative mechanism

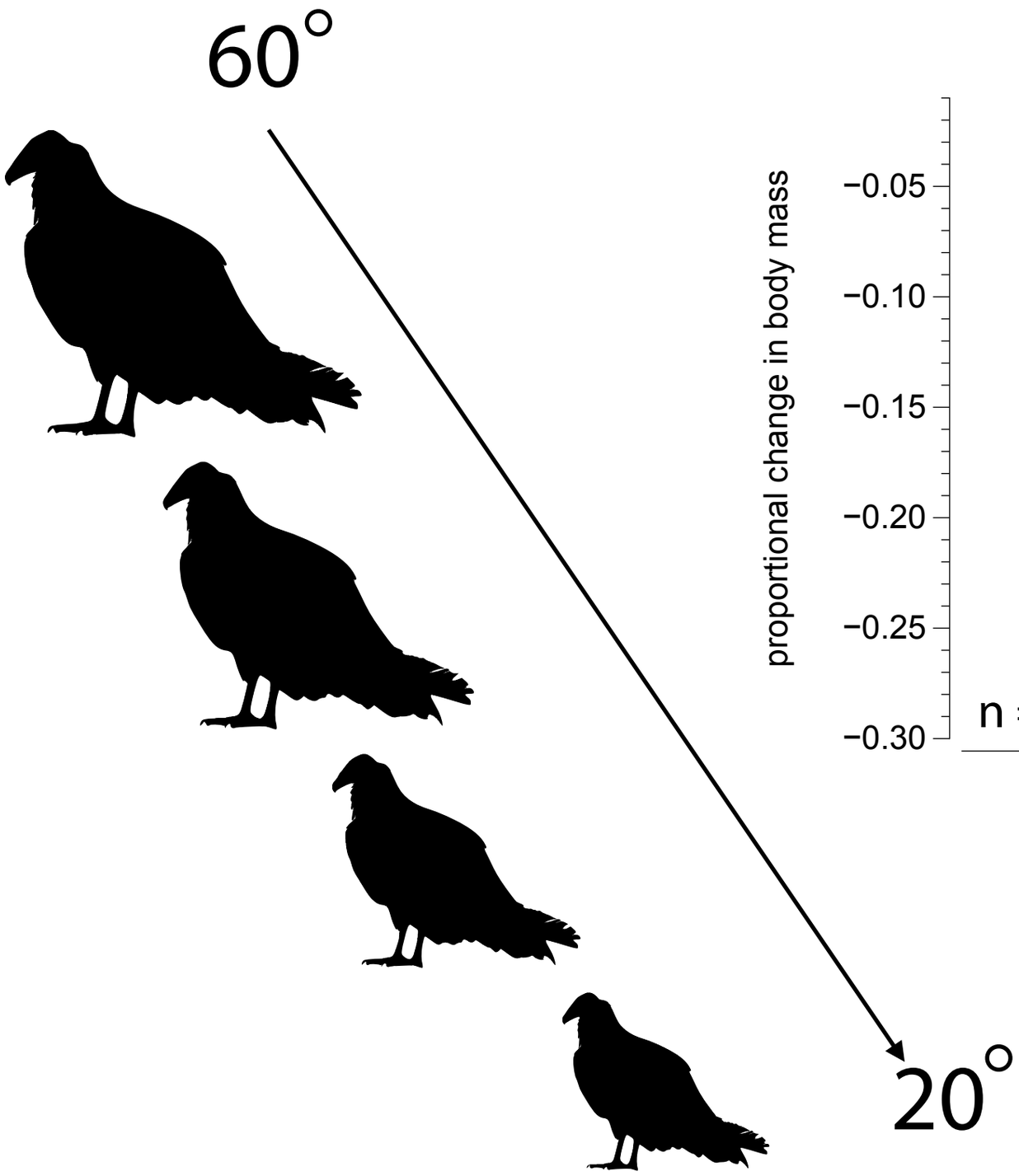


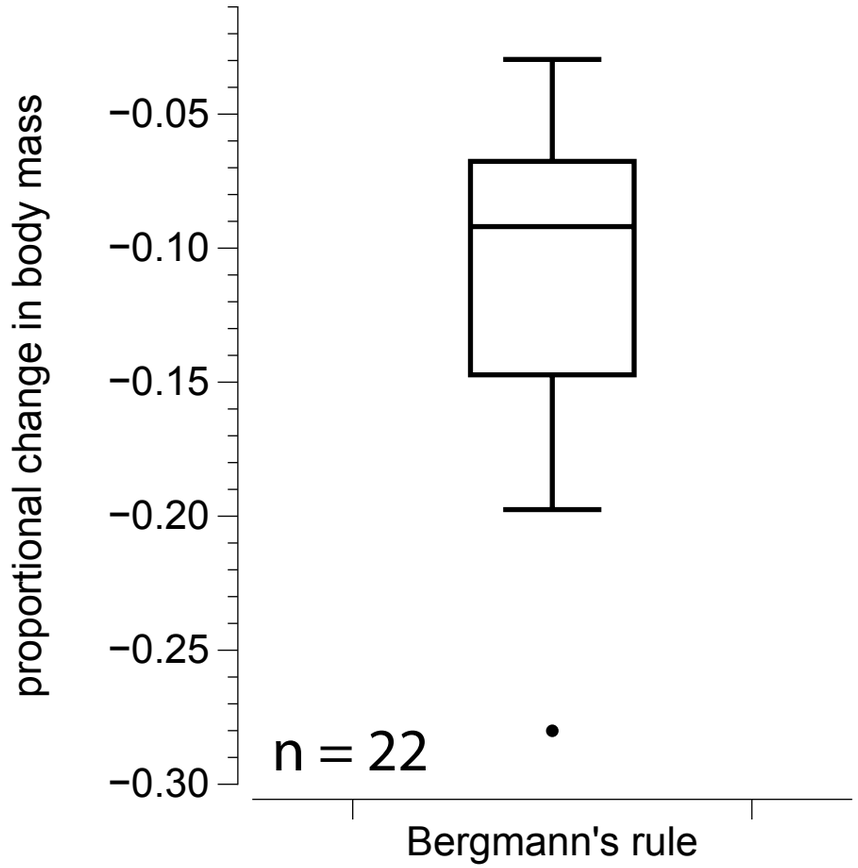
Intra- and interspecific latitudinal variation in body size



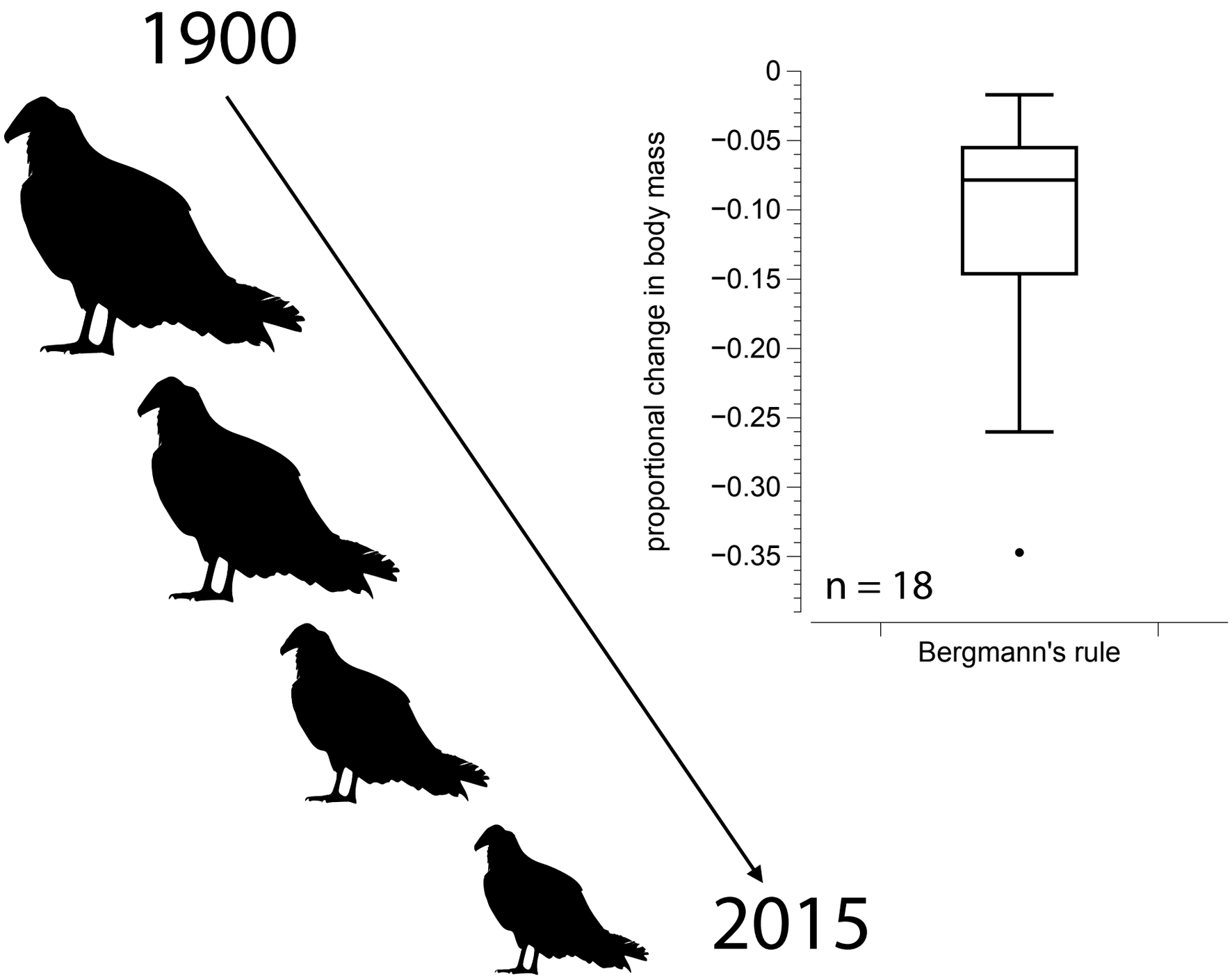
- Mass declines with warmer climates
- But sometimes mass increases with warmer climates
- Bigger species tend to follow Bergmann's rule

Bergmann's rule: Intra- and interspecific latitudinal variation in body size

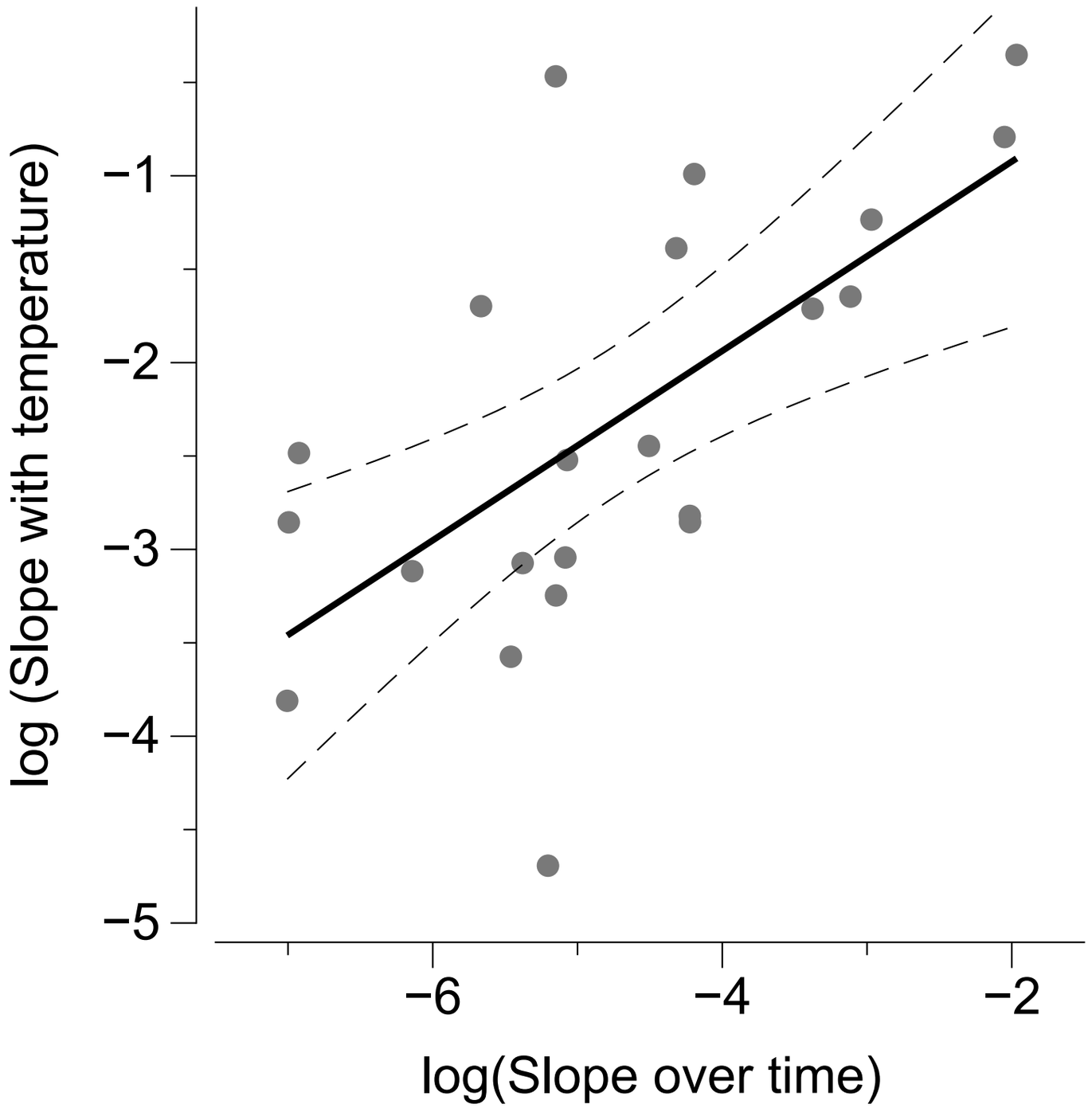




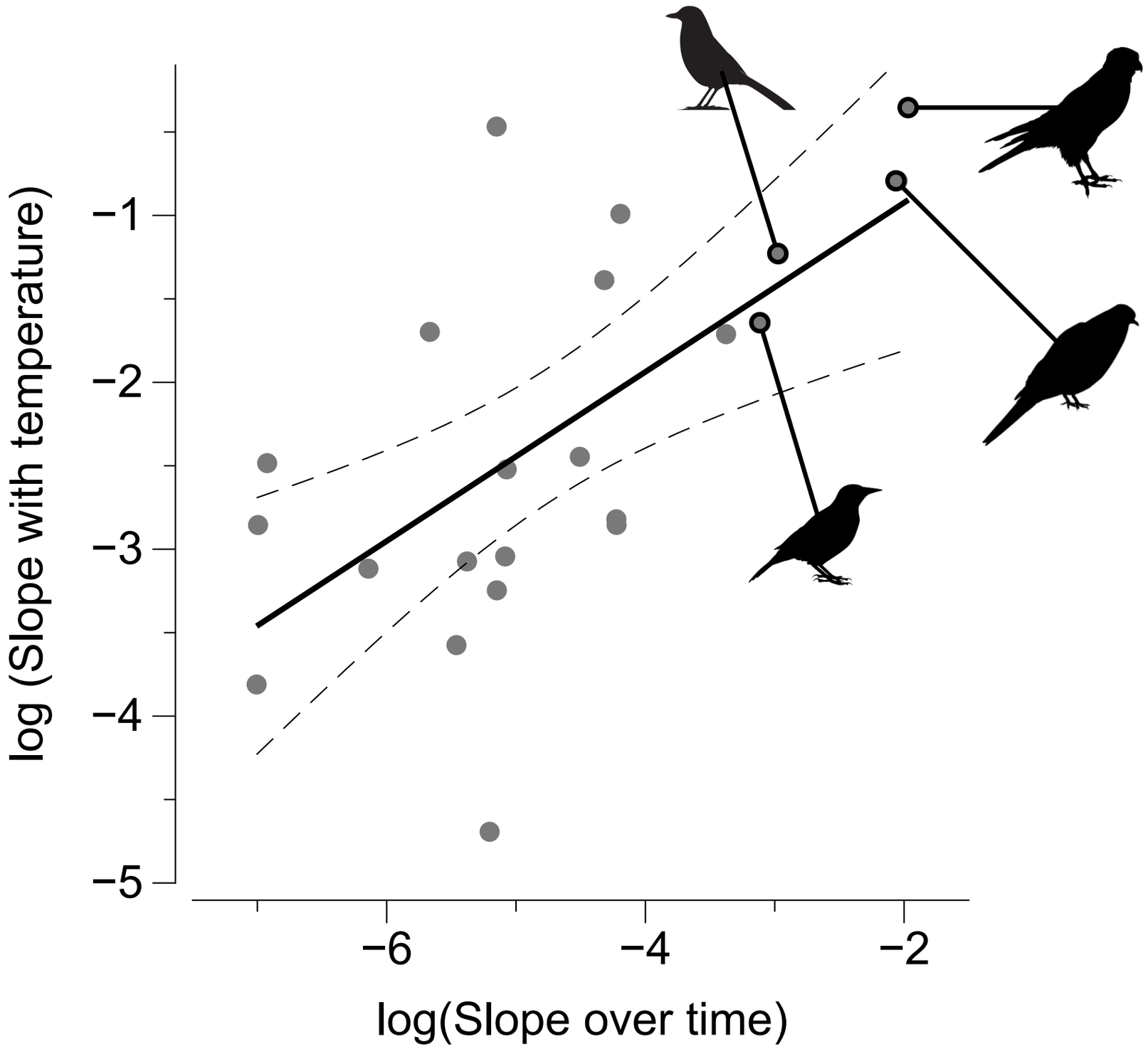
Bergmann's rule: Intra- and interspecific latitudinal variation in body size



Birds that declined with warm temperatures also declined over last century



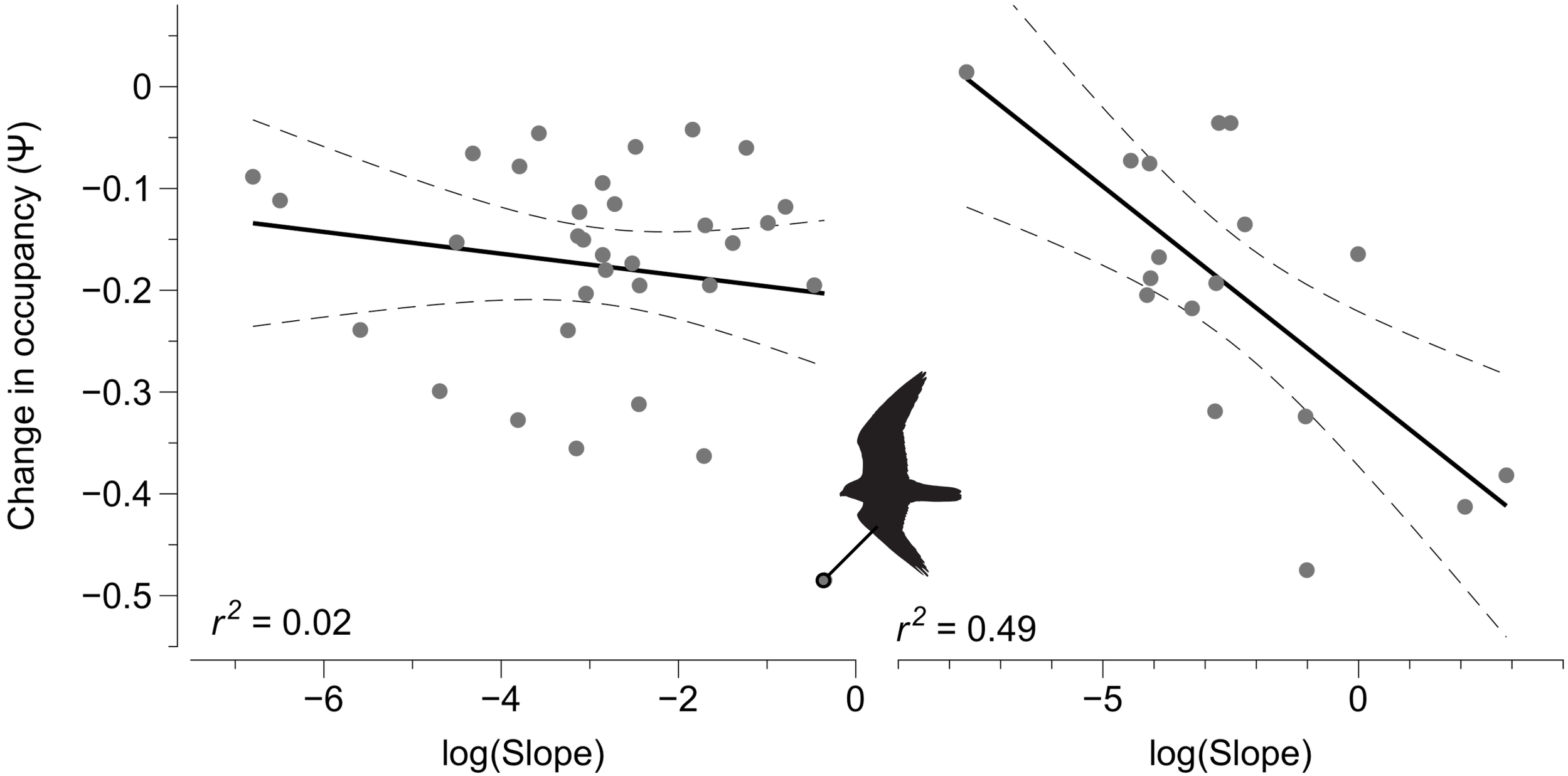
Birds that declined with warm temperatures also declined over last century



Shrinking body mass as a 3rd global response to climate change

follow Bergmann's rule

counter-Bergmann's rule



Bird decline related to evaporative cooling demand

predictions about change in mass to maintain same level

Physiological stress

Physiological response

Emigrate

Activity

Foraging
Reproduction
Defend

Fitness

Population-level

Organism-level

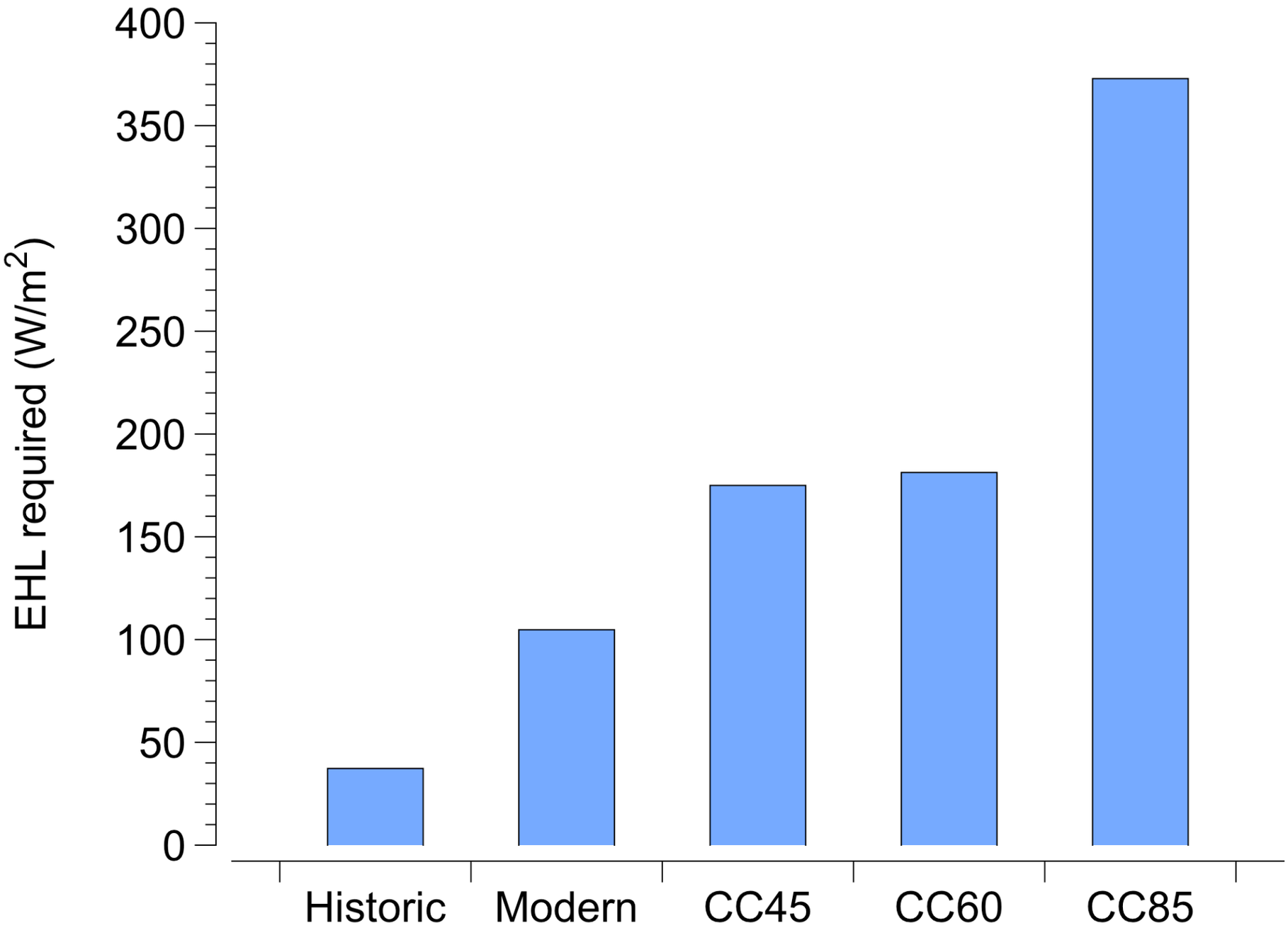
Physiological adaptation

Body size

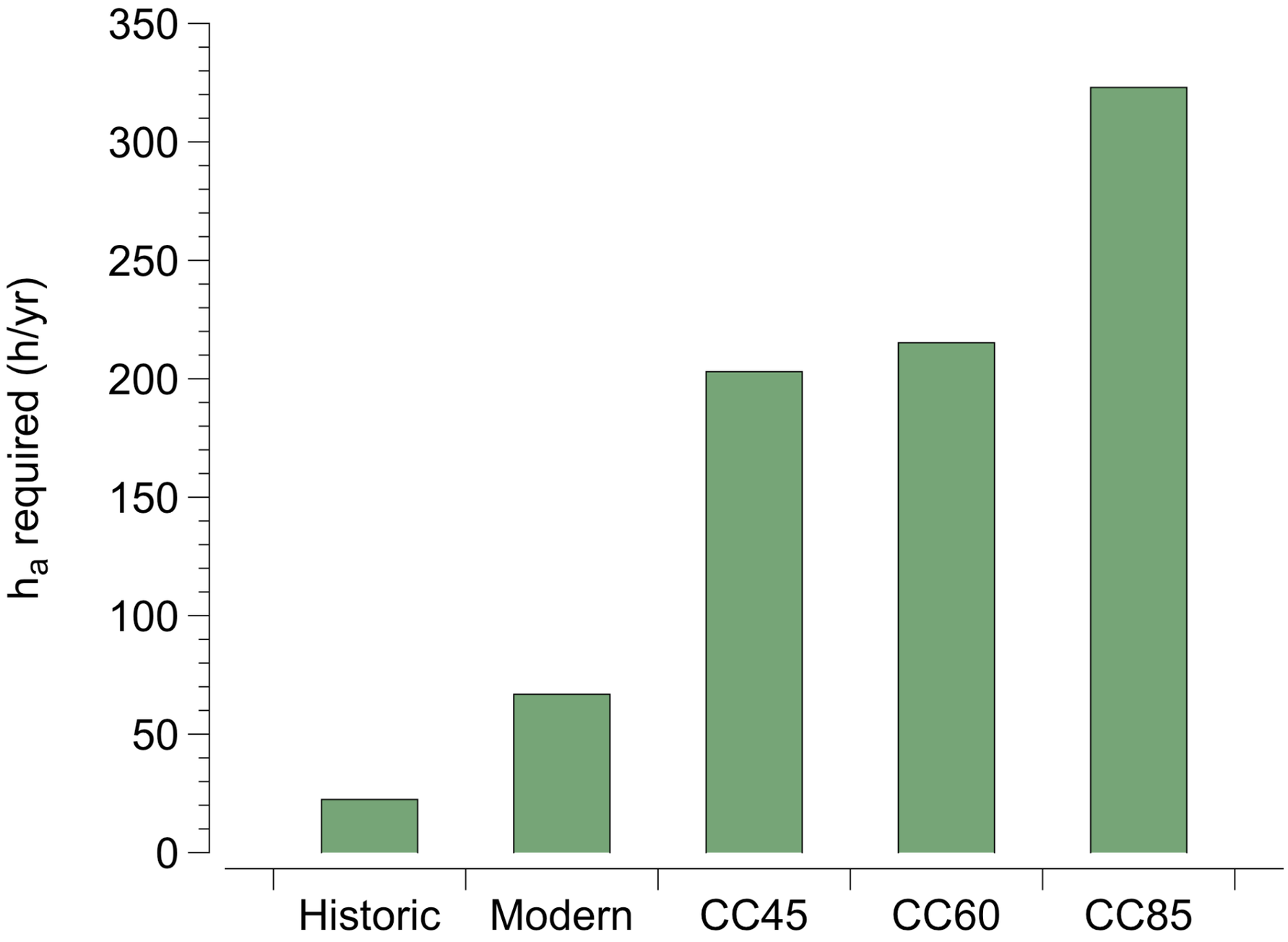
Local extirpation

Ph

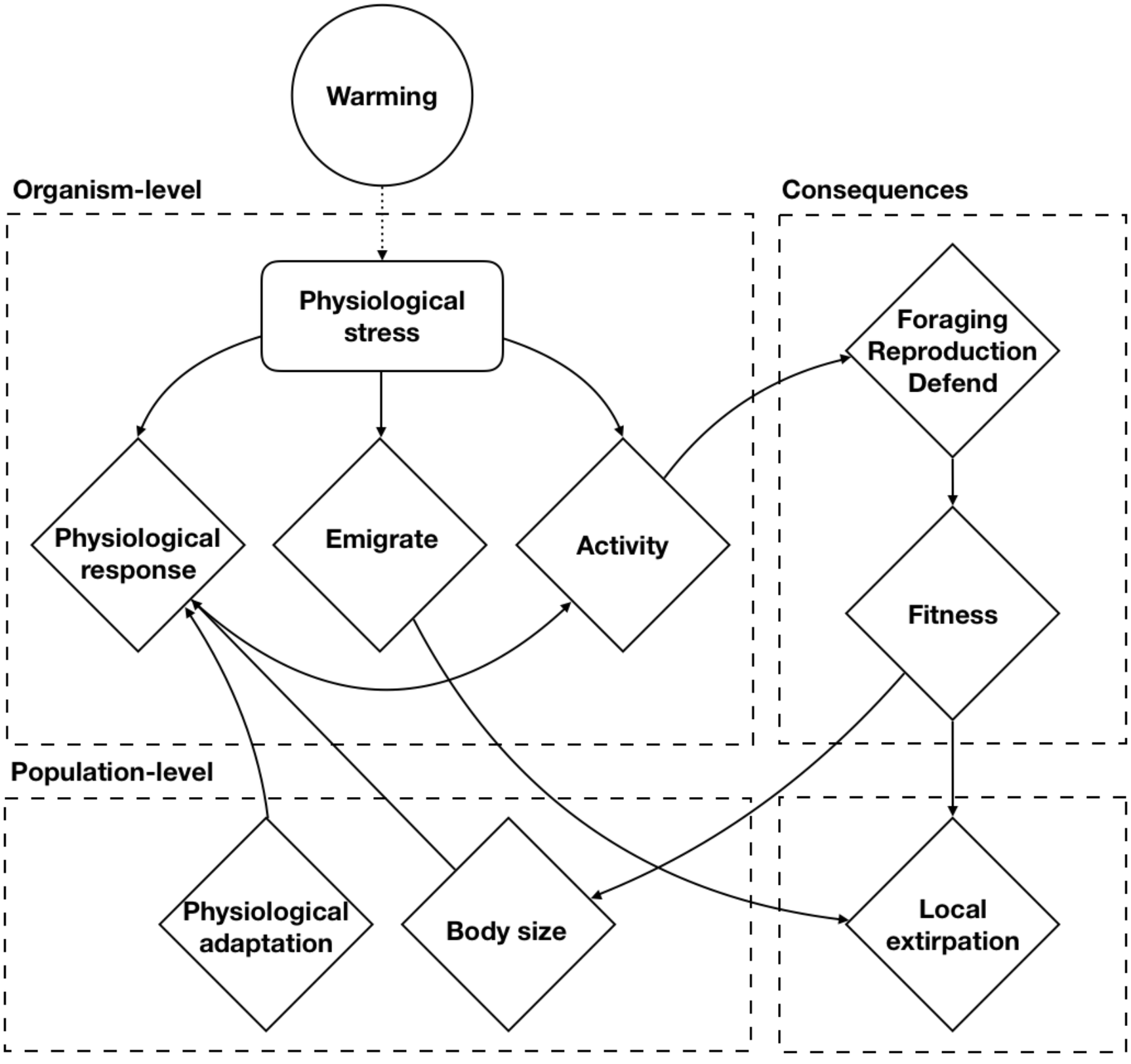
Bird decline related to evaporative cooling demand



Bird decline related to evaporative cooling demand



Biophysical model helps us to evaluate responses to climate change



Biophysical model helps us to evaluate responses to climate change