

# **ALLEN'S RULE in the *URSINAE* SUBFAMILY**

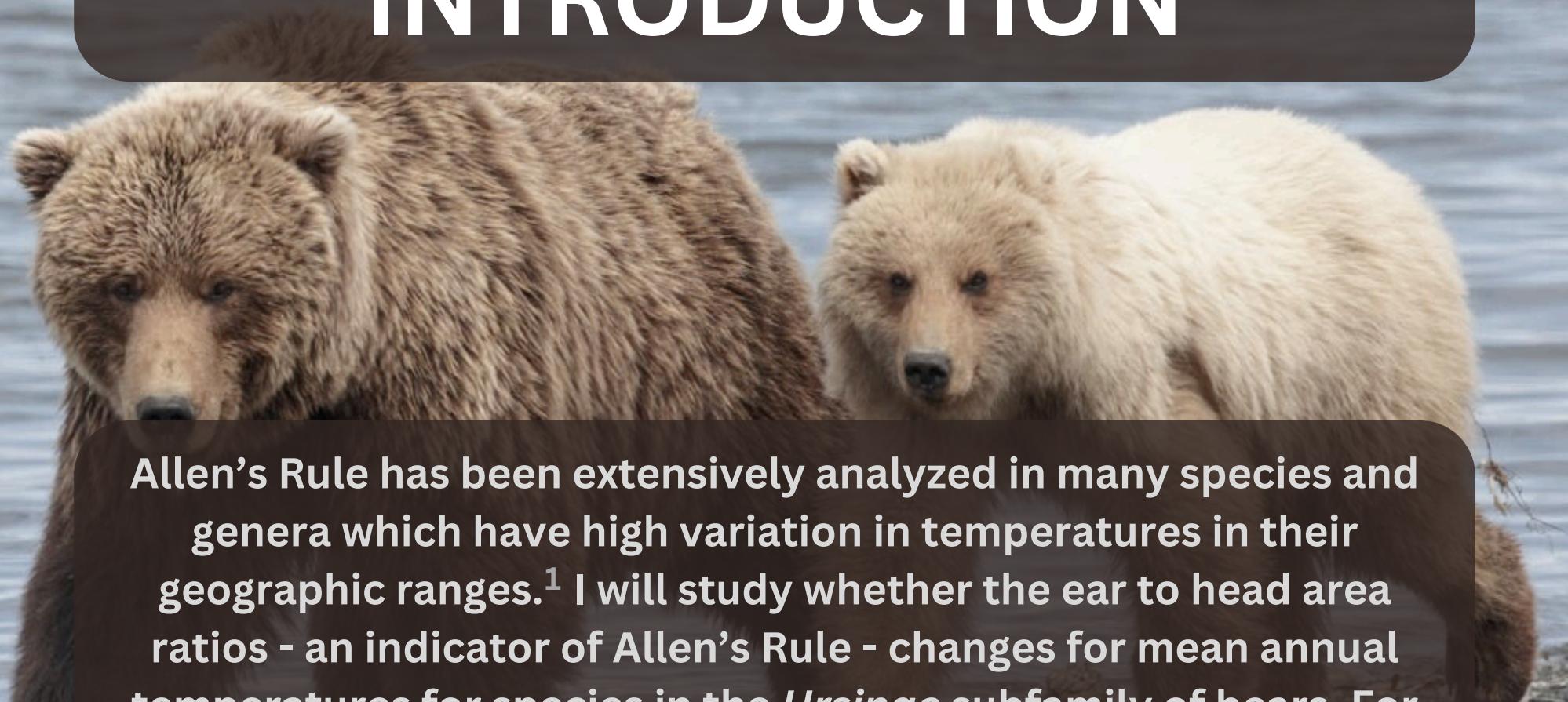
an inter- and  
intraspecies analysis

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# INTRODUCTION



Allen's Rule has been extensively analyzed in many species and genera which have high variation in temperatures in their geographic ranges.<sup>1</sup> I will study whether the ear to head area ratios - an indicator of Allen's Rule - changes for mean annual temperatures for species in the *Ursinae* subfamily of bears. For the selected species, correlations and patterns will be analyzed both inter- and intraspecies, and statistic-based conclusions will be made on bears' plasticity/selection depending on climate.

# METHODS

## SPECIES SELECTION

The highest-level selection is a subfamily of bears, *Ursinae*, which were chosen due to their large geographic range<sup>2</sup> and observations worldwide. Within the subfamily is the *Ursus* genus, which includes asian and american black bears, brown bears, and polar bears species. Sun bears and sloth bears were also included, being in *Ursinae*.

## OBSERVATION COLLECTION

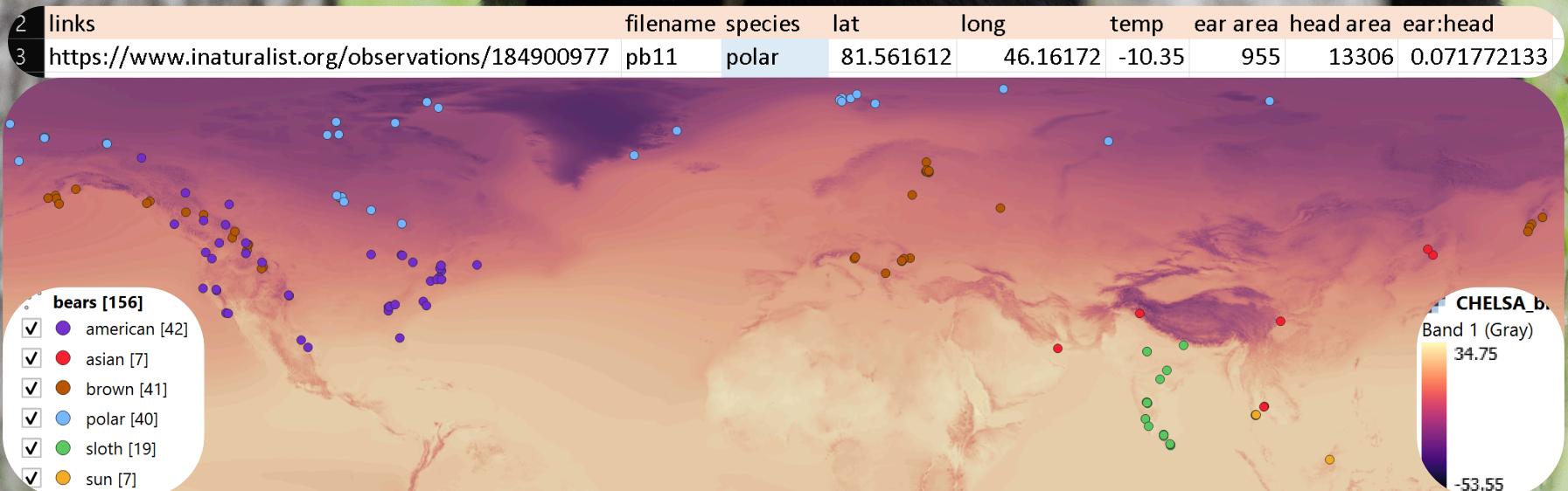
Observations were taken from INaturalist<sup>3</sup>, which were all wild and research grade images with front-facing bears with clear head and ear shapes. A total of 155 observations were taken across the six species, based on abundance of observations. A macro with ImageJ<sup>4</sup> was used to consistently measure the ear and head areas for each image

## TEMPERATURES

CHELSA Bioclim<sup>5</sup> has a collection of high resolution GeoTIFF files encoded with mean annual temperatures, and this was used as a raster layer in QGIS<sup>6</sup> which was able to combine values from the observation table's latitudes and longitudes to create a new temperature (°C) column.

## STATISTICS

I used Python to code visualizations and perform regression analysis. The results were cross-checked with Excel data analysis.



# RESULTS

## BROWN BEAR

$R = 0.470$   
 $p\text{-value} = 1.92e-03$   
weak to moderate positive correlation

## OTHER SPECIES

$|R| < 0.25$   
 $p\text{-value} > 0.05$   
no correlation, or too little data

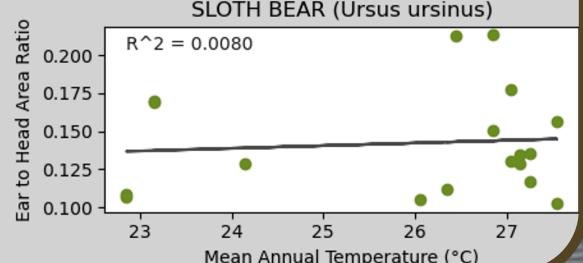
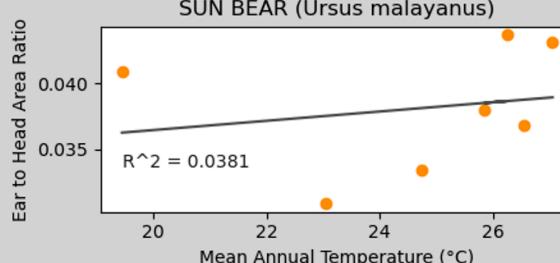
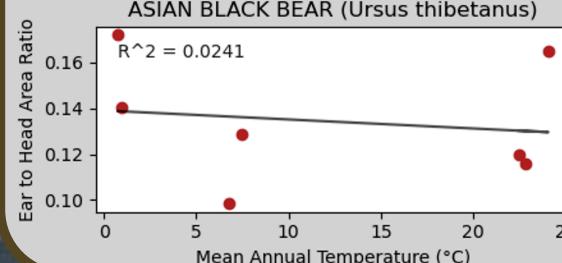
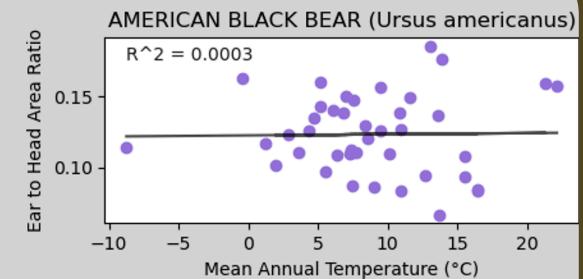
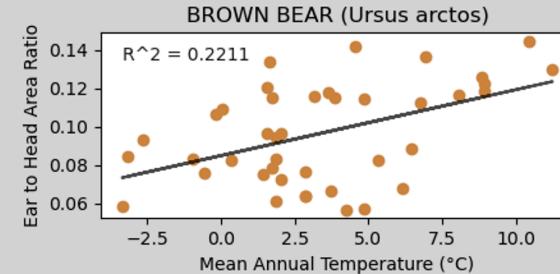
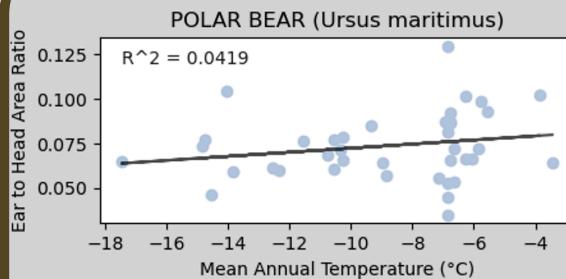
## URSINAE (ALL)

$R = 0.427$   
 $p\text{-value} = 3.01e-08$   
weak to moderate positive correlation

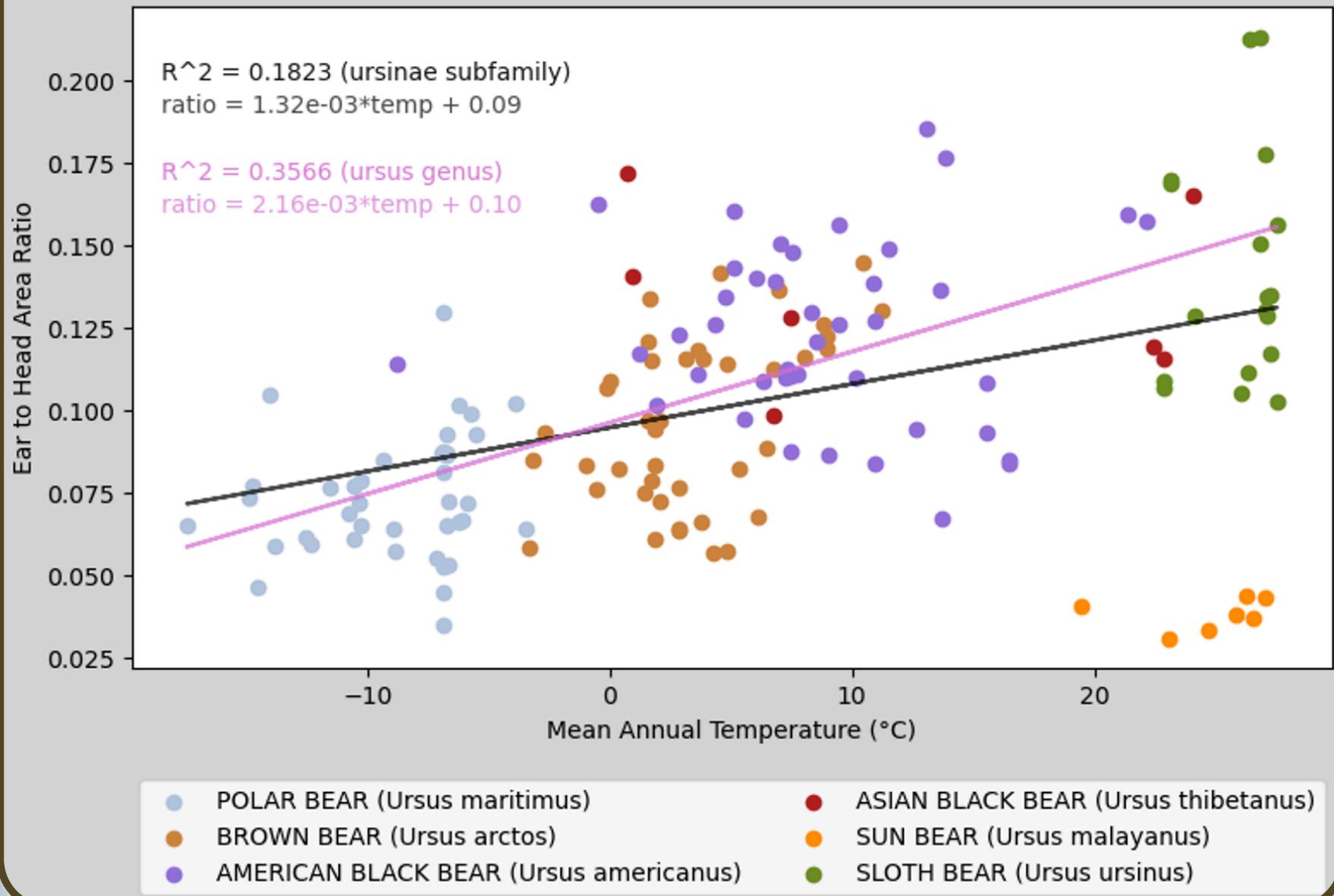
## URSUS GENUS

$R = 0.597$   
 $p\text{-value} = 6.45e-14$   
moderate positive correlation

## INDIVIDUAL SPECIES

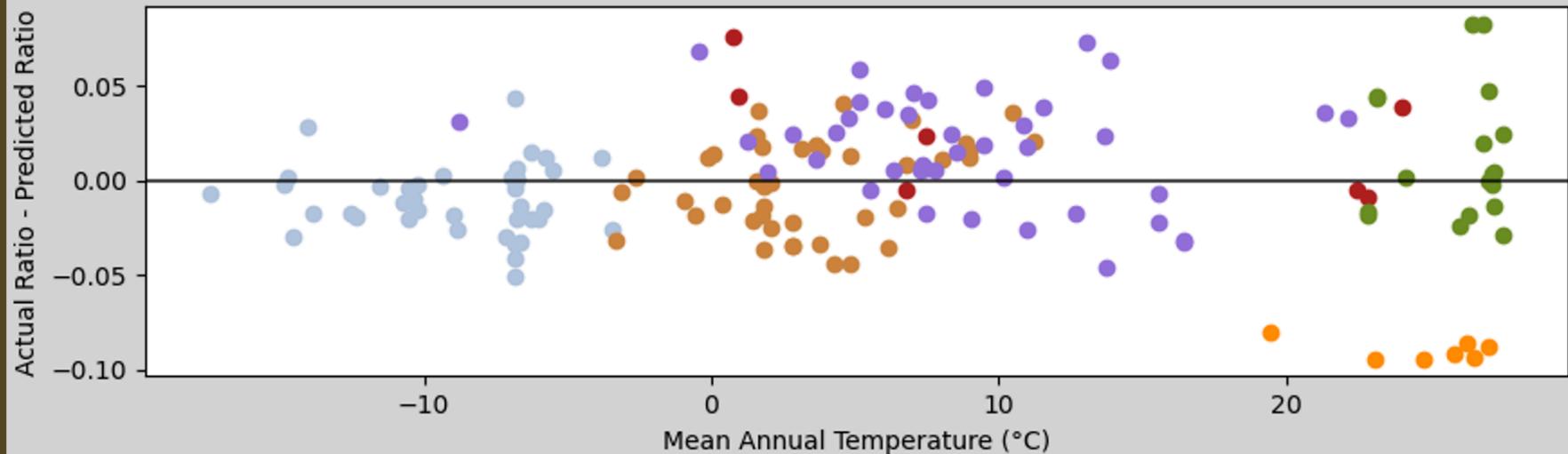


## ALL SPECIES

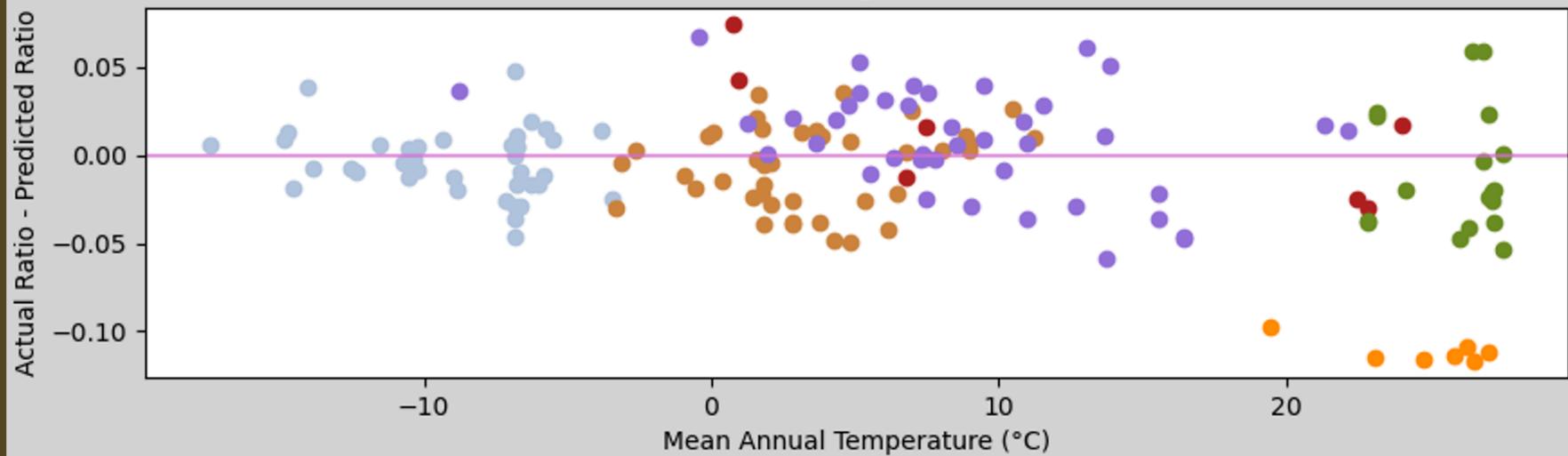


## RESIDUALS

ursinae subfamily



ursus genus



- POLAR BEAR (*Ursus maritimus*)
- BROWN BEAR (*Ursus arctos*)
- AMERICAN BLACK BEAR (*Ursus americanus*)
- ASIAN BLACK BEAR (*Ursus thibetanus*)
- SUN BEAR (*Ursus malayanus*)
- SLOTH BEAR (*Ursus ursinus*)

# DISCUSSION

## RESULTS ANALYSIS

There were three groups that showed statistically significant correlations between mean annual temperature and ear to head area ratios: brown bears, *Ursinae*, and *Ursus*. The strongest correlation was seen in *Ursus*. In all three groups, there was a good sample of data points spread across a wide temperature range. For this reason, it is reasonable to conclude that Allen's Rule holds in each of these three groups - within a species, a genus, and a subfamily.

## ERROR SOURCES

The largest source is likely human error in ratio measurement. This was especially relevant for bears with a lot of fur. Sexual dimorphism and age<sup>7</sup> also likely have an effect. The large dataset helps minimize the errors.

# SUMMARY

## BIG PICTURE

Allen's Rule is related to heat dissipation, but other factors can help retain or expel heat.<sup>8</sup> This fact can help explain some outliers. The existence of Allen's Rule suggests plasticity or selection in bears dependent on their climate.

## NEXT STEPS

Larger dataset, more indicators.

FILES  
and  
DATA  
--->



## LITERATURE CITED

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