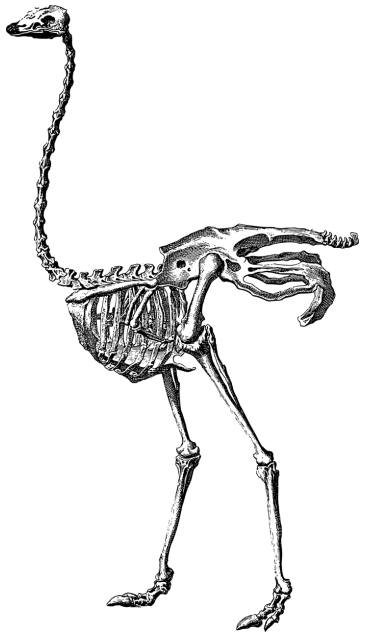
Birds of a Femur

Exploratory Data Analysis:
Comparative Skeletal Morphology

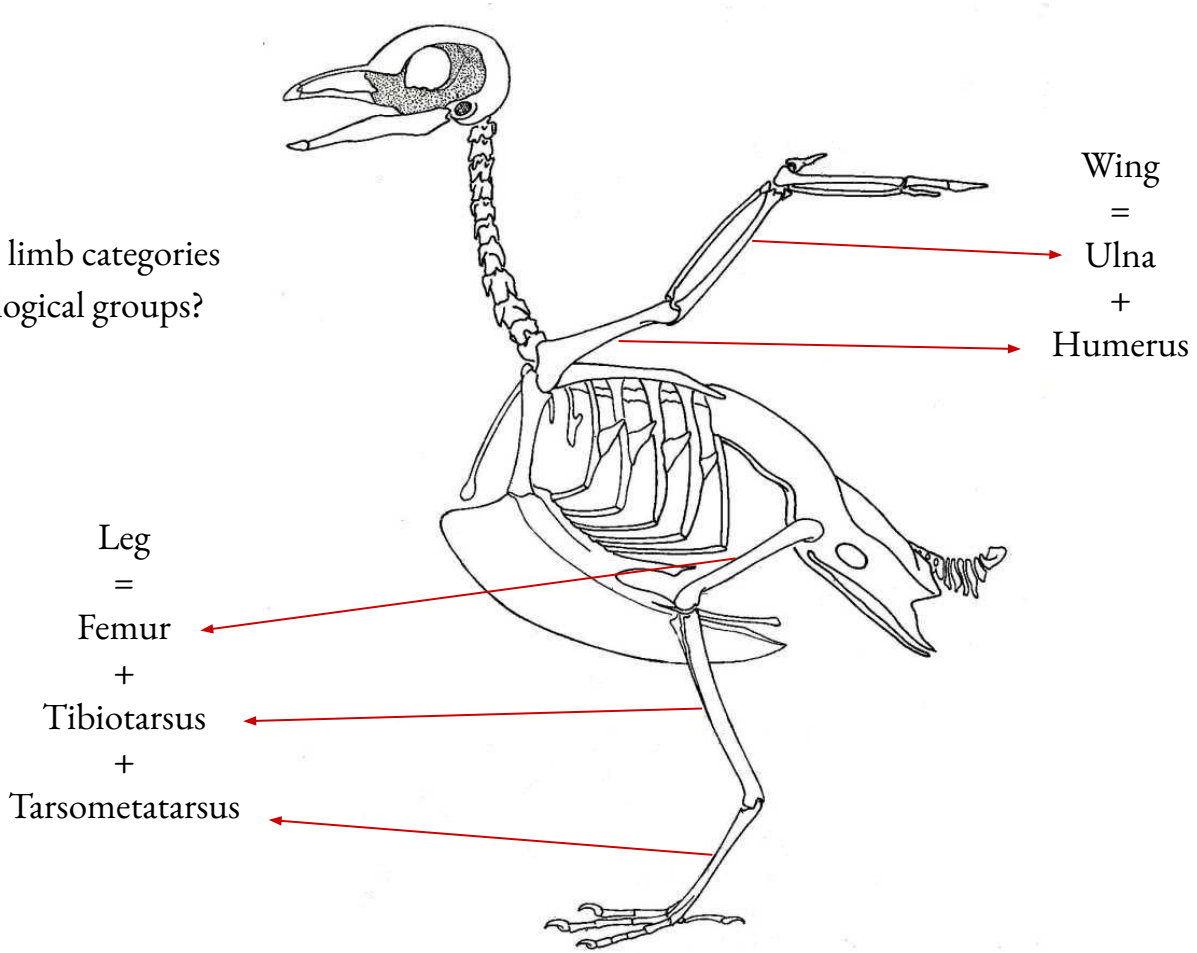
The Data

- “Birds’ Bones and Living Habits,” found on Kaggle (by JT)
- Consists of selective measurements of bird bones, taken from specimens at the Natural History Museum of Los Angeles County
- Measurements are:
    - Length and diameter of Humerus
    - Length and diameter of Ulna
    - Length and diameter of Femur
    - Length and diameter of Tibiotarsus
    - Length and diameter of Tarsometatarsus
- Observations also classified by “ecological group”:
    - Swimming Birds
    - Wading Birds
    - Raptors
    - Scansorial Birds
    - Terrestrial Birds
    - Singing Birds



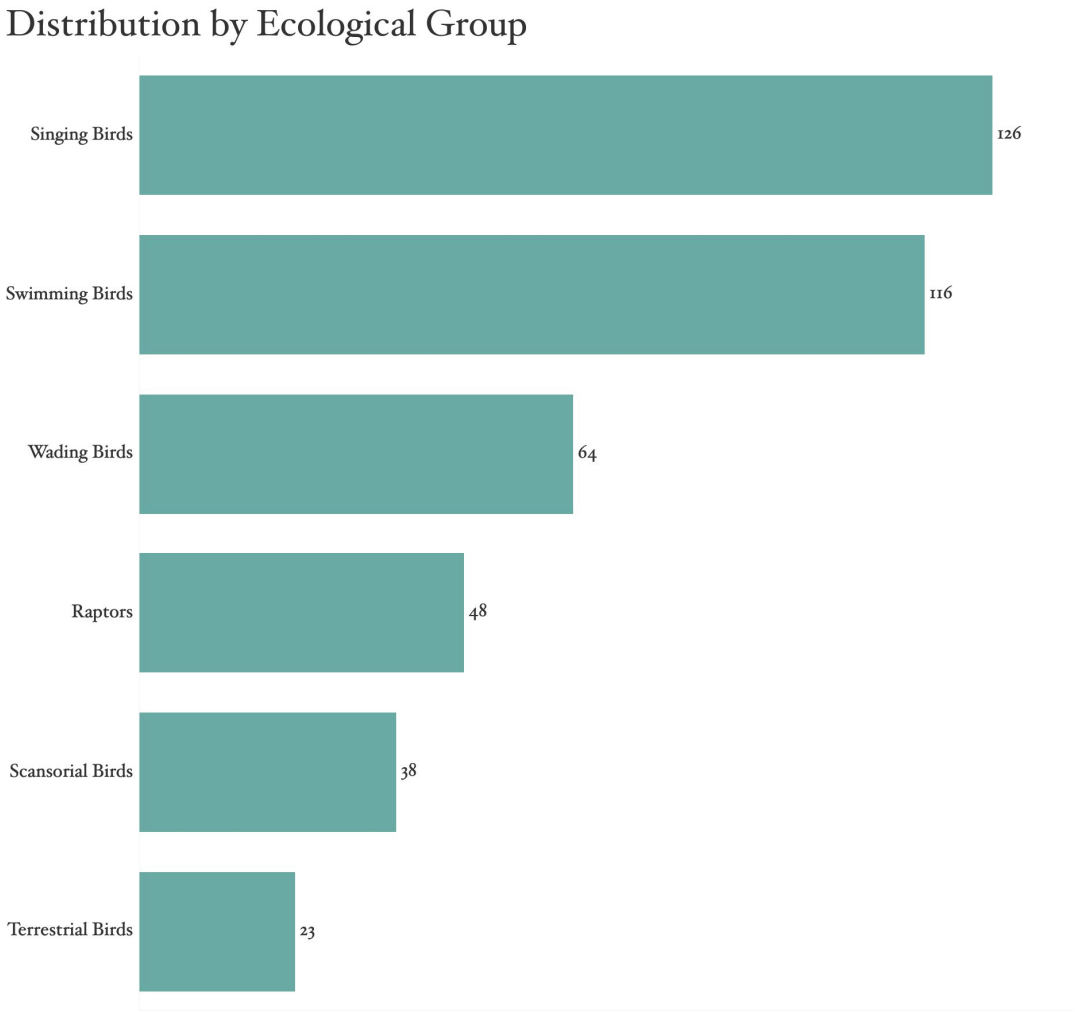
The Aim

- Focus on length measurements
- Lump measurements into broader limb categories
- Proportion differences among ecological groups?

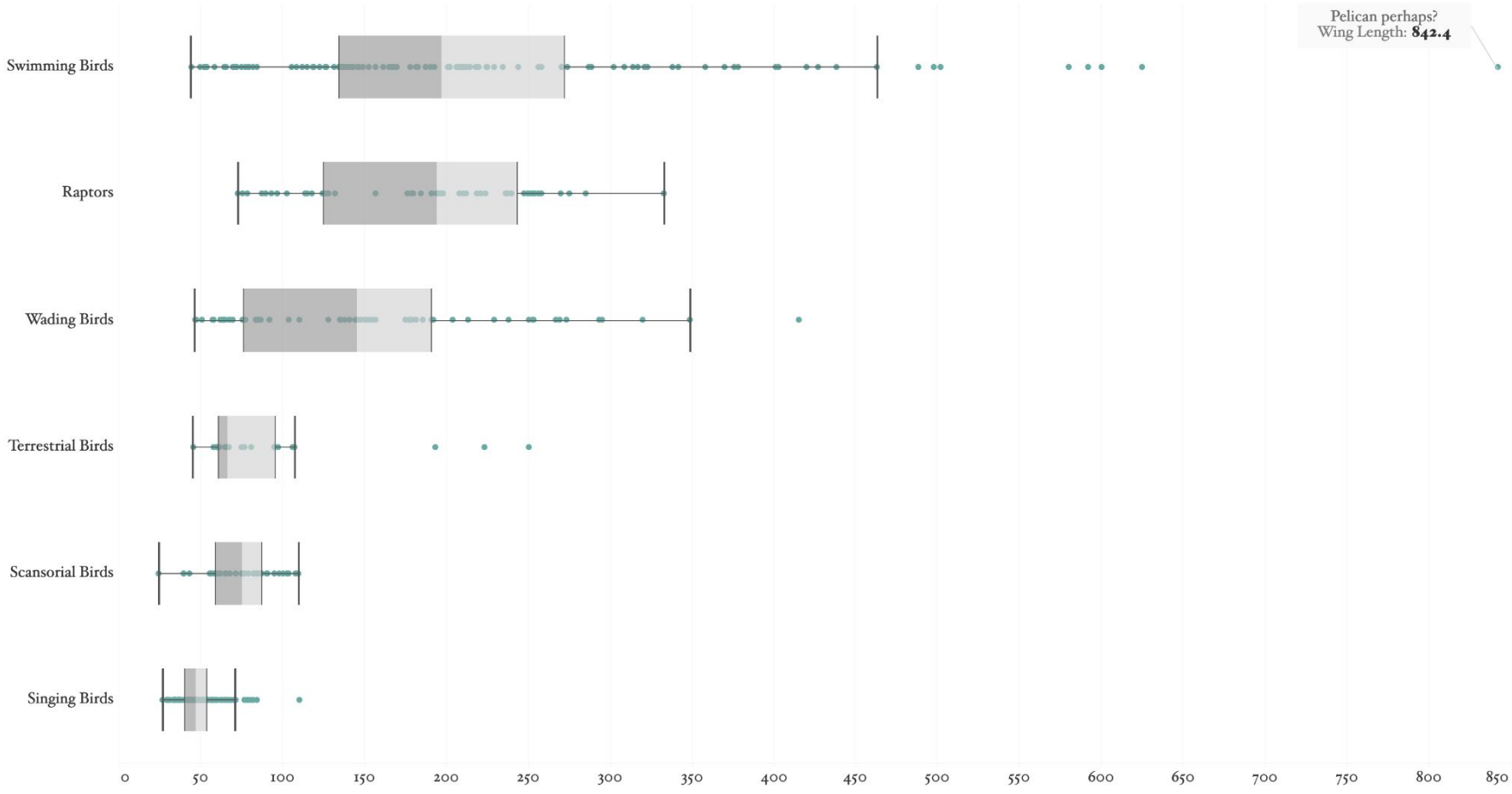


Caveats / Issues

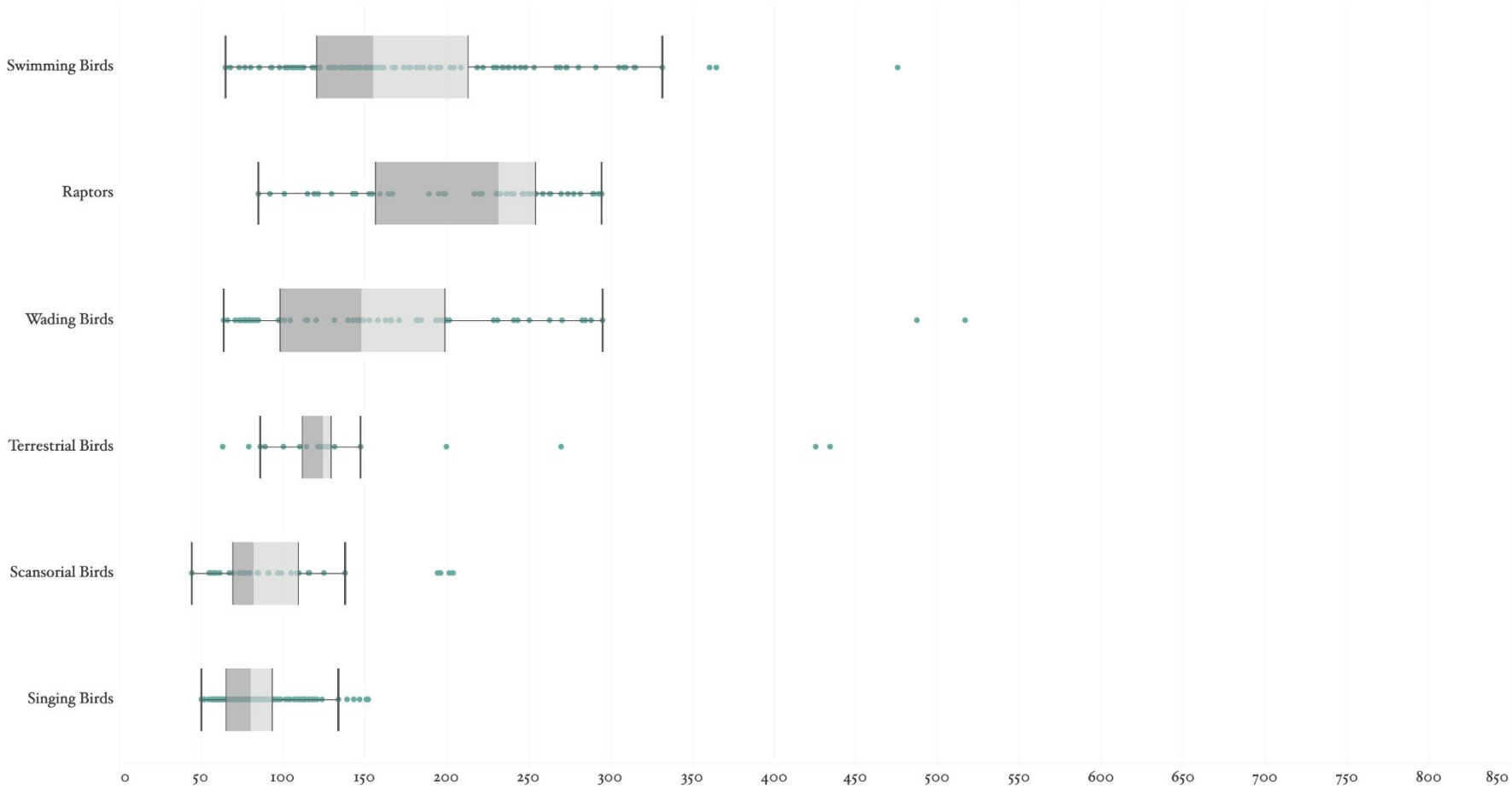
- Samples aren't equally distributed with regard to ecological group
- Limb analysis is only applicable to this case
- Ecological groups don't seem to be a standardized taxon
- No species info in the data, so it's unclear how the samples represent the groups



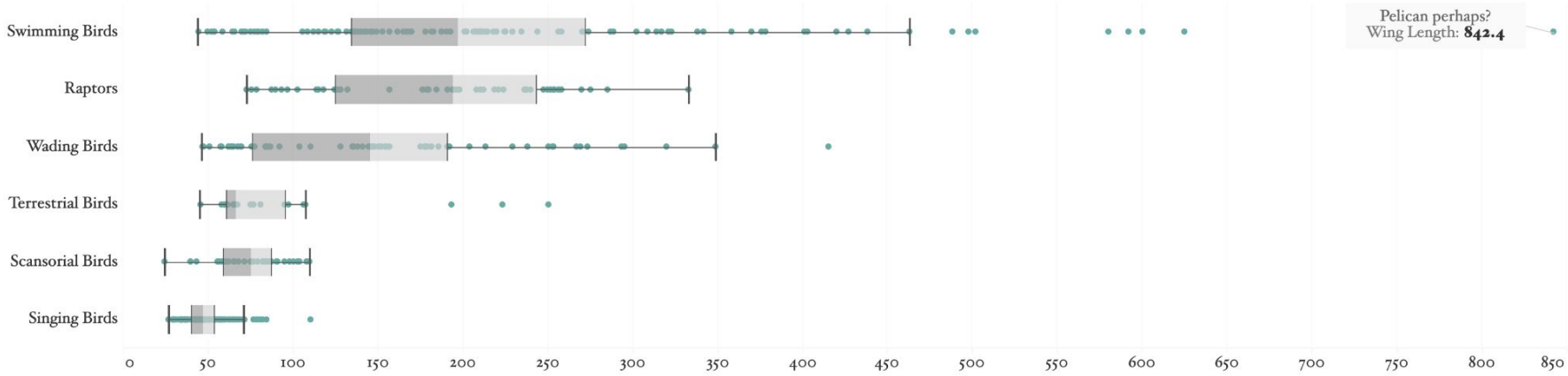
Wing Length Distribution



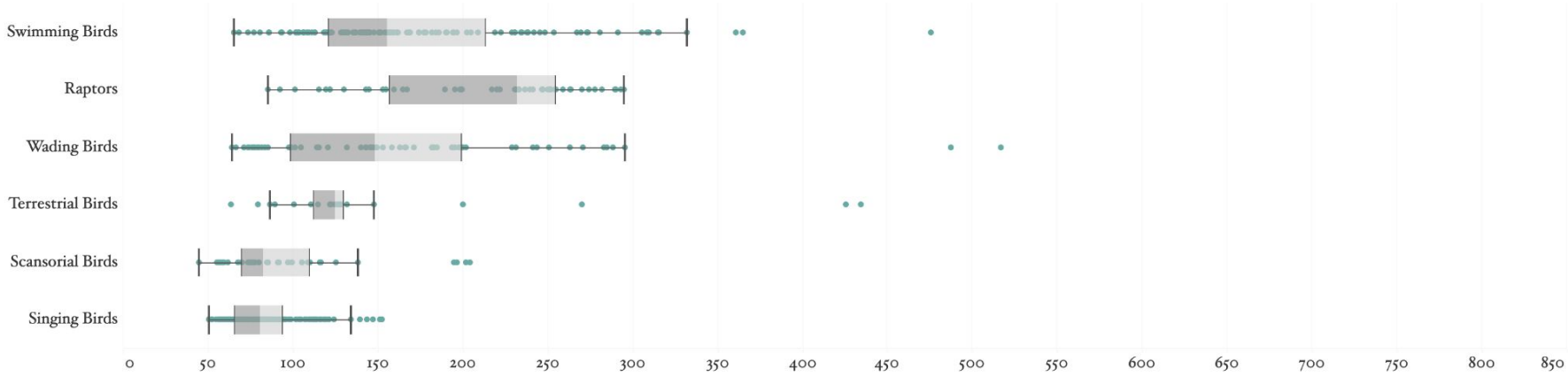
Leg Length Distribution



Wing Length Distribution



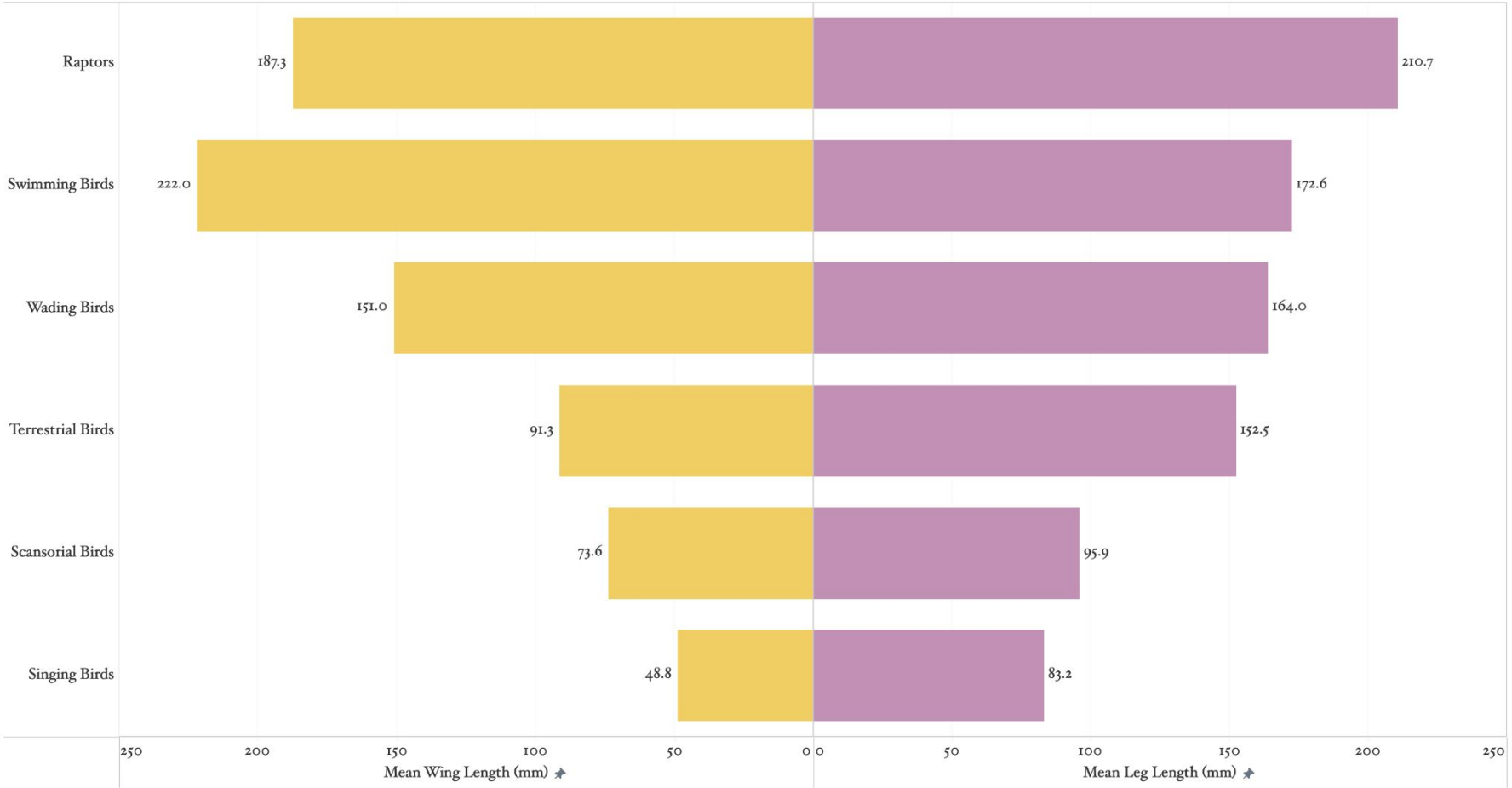
Leg Length Distribution



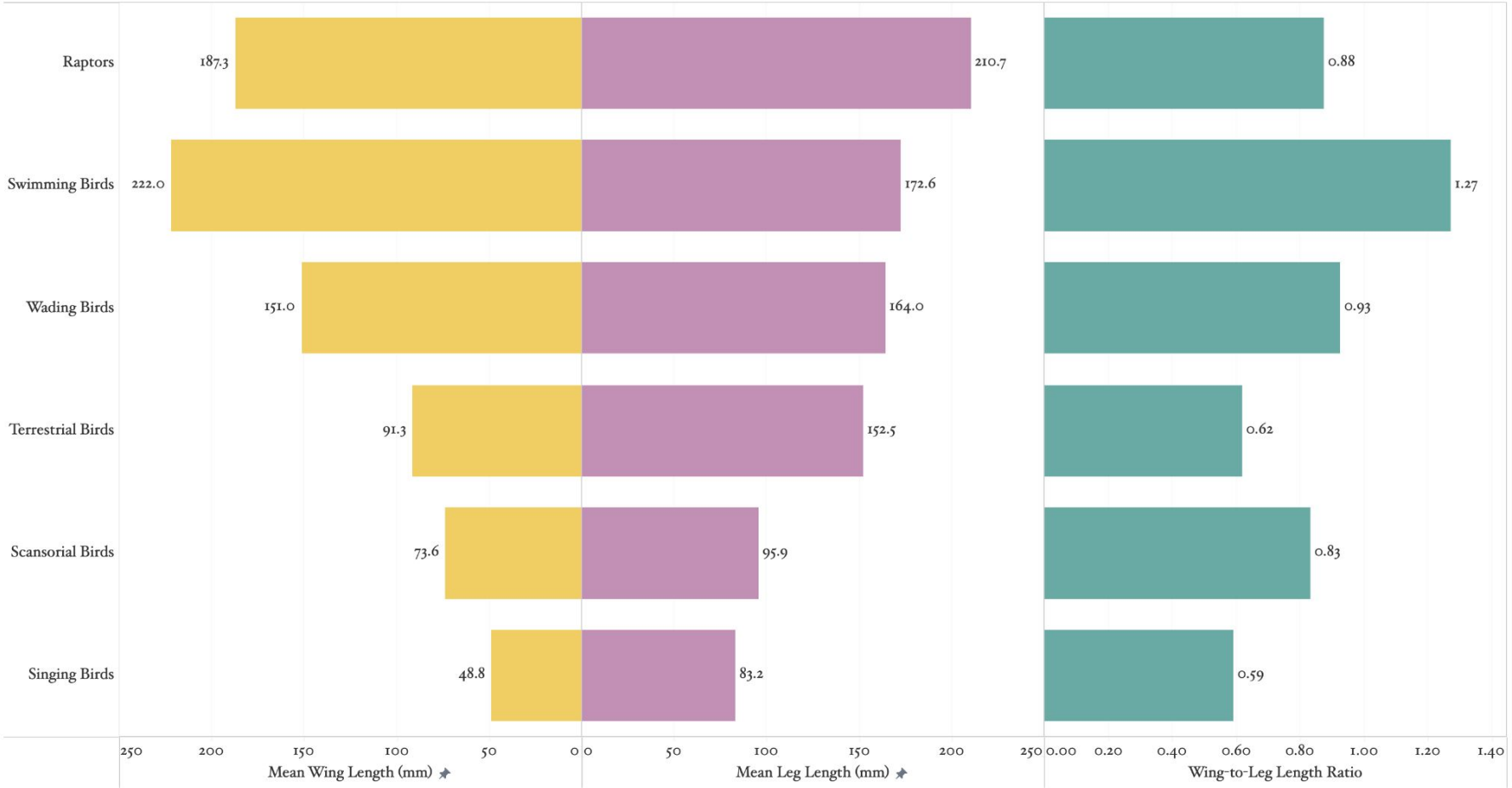
Moving to Bivariate Analysis: Focusing on Mean

Ecological Group	Mean Wing Length	Mean Leg Length	Combined Length
Raptors	187.3	210.7	397.9
Swimming Birds	222.0	172.6	394.6
Wading Birds	151.0	164.0	315.1
Terrestrial Birds	91.3	152.5	243.8
Scansorial Birds	73.6	95.9	169.5
Singing Birds	48.8	83.2	132.0

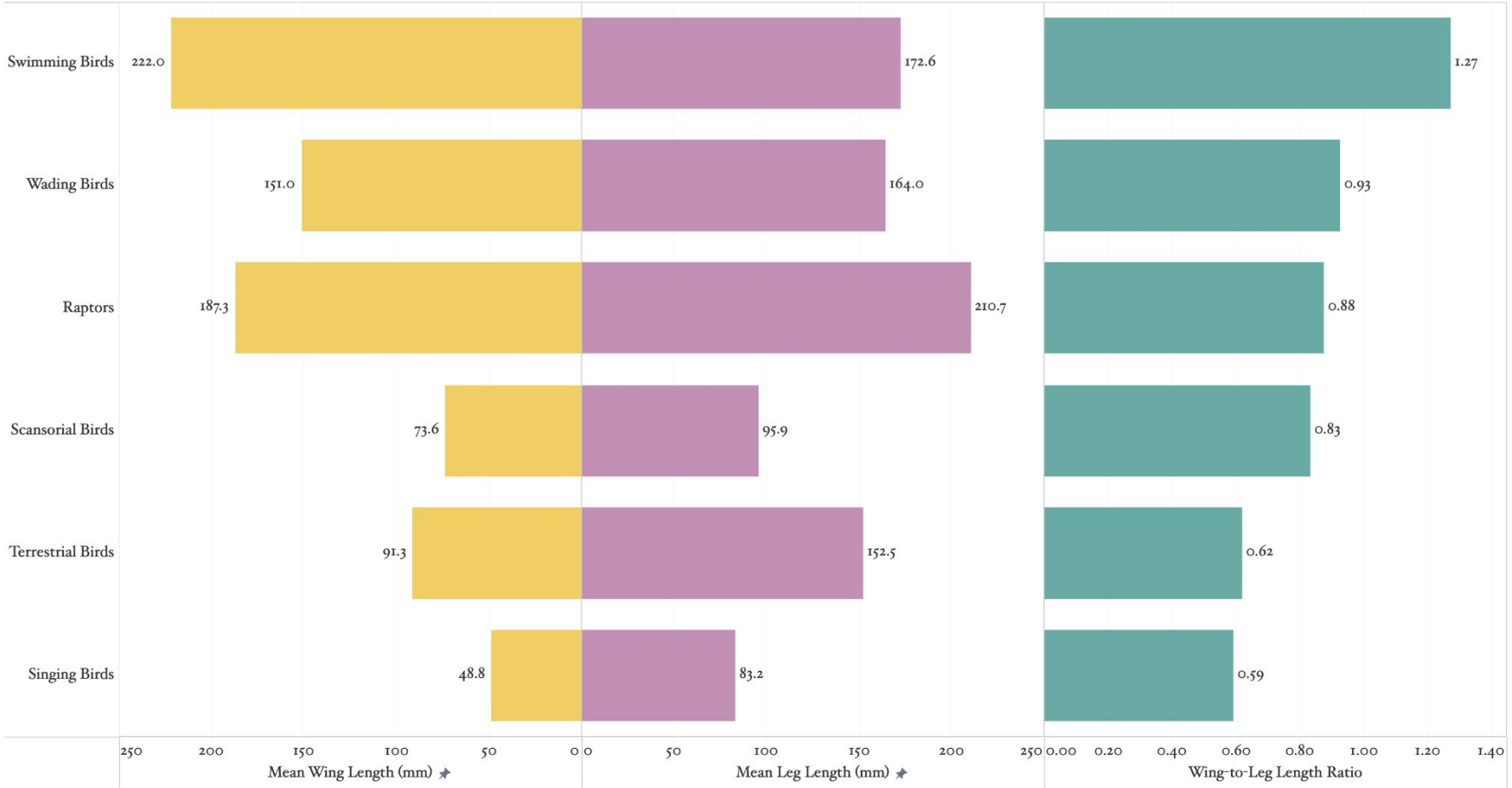
Mean Wing vs. Mean Leg Length



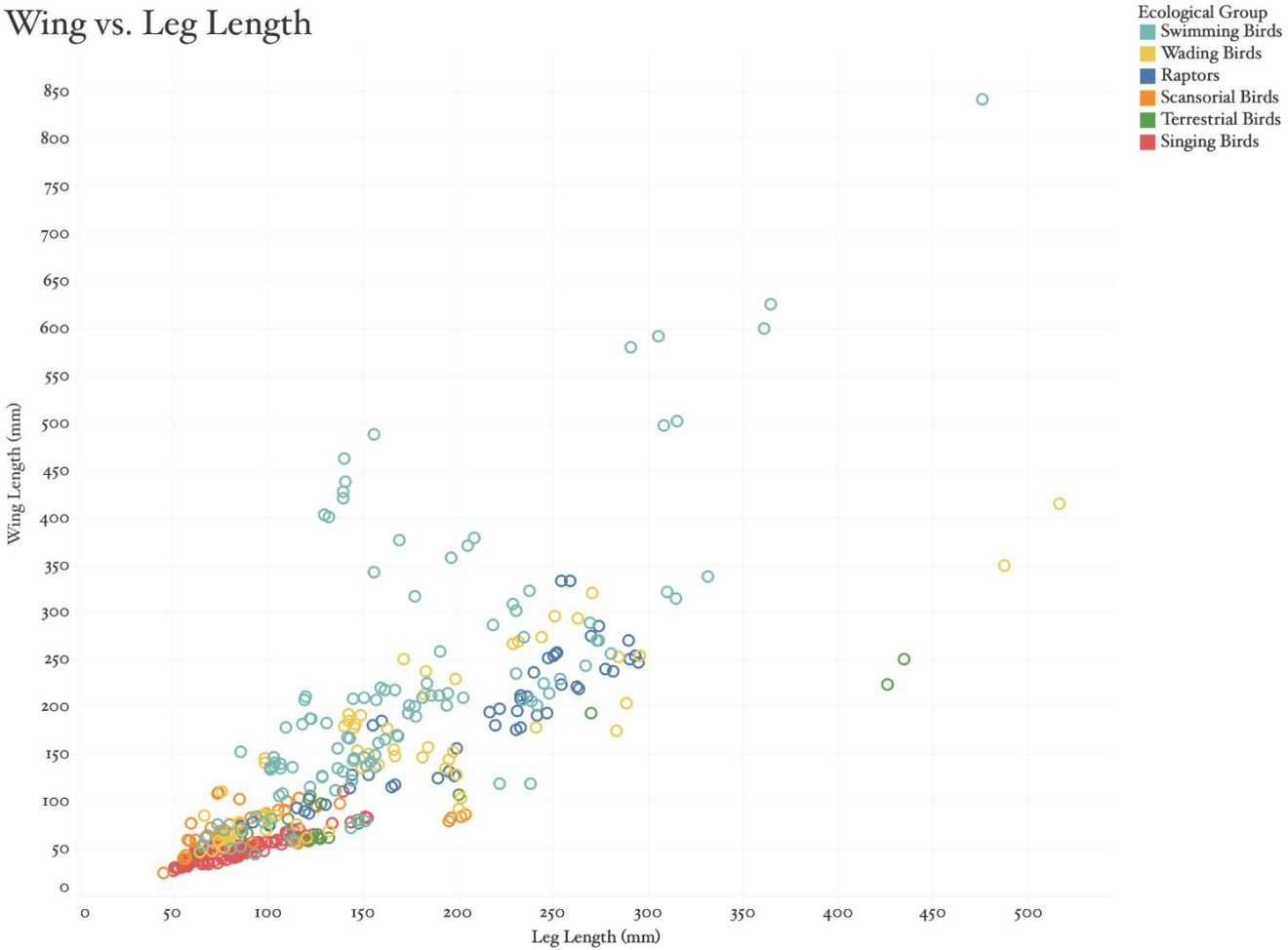
Mean Wing vs. Mean Leg Length + Ratio



Mean Wing vs. Mean Leg Length + Ratio



Wing vs. Leg Length



Wing vs. Leg Length: Linear Regression

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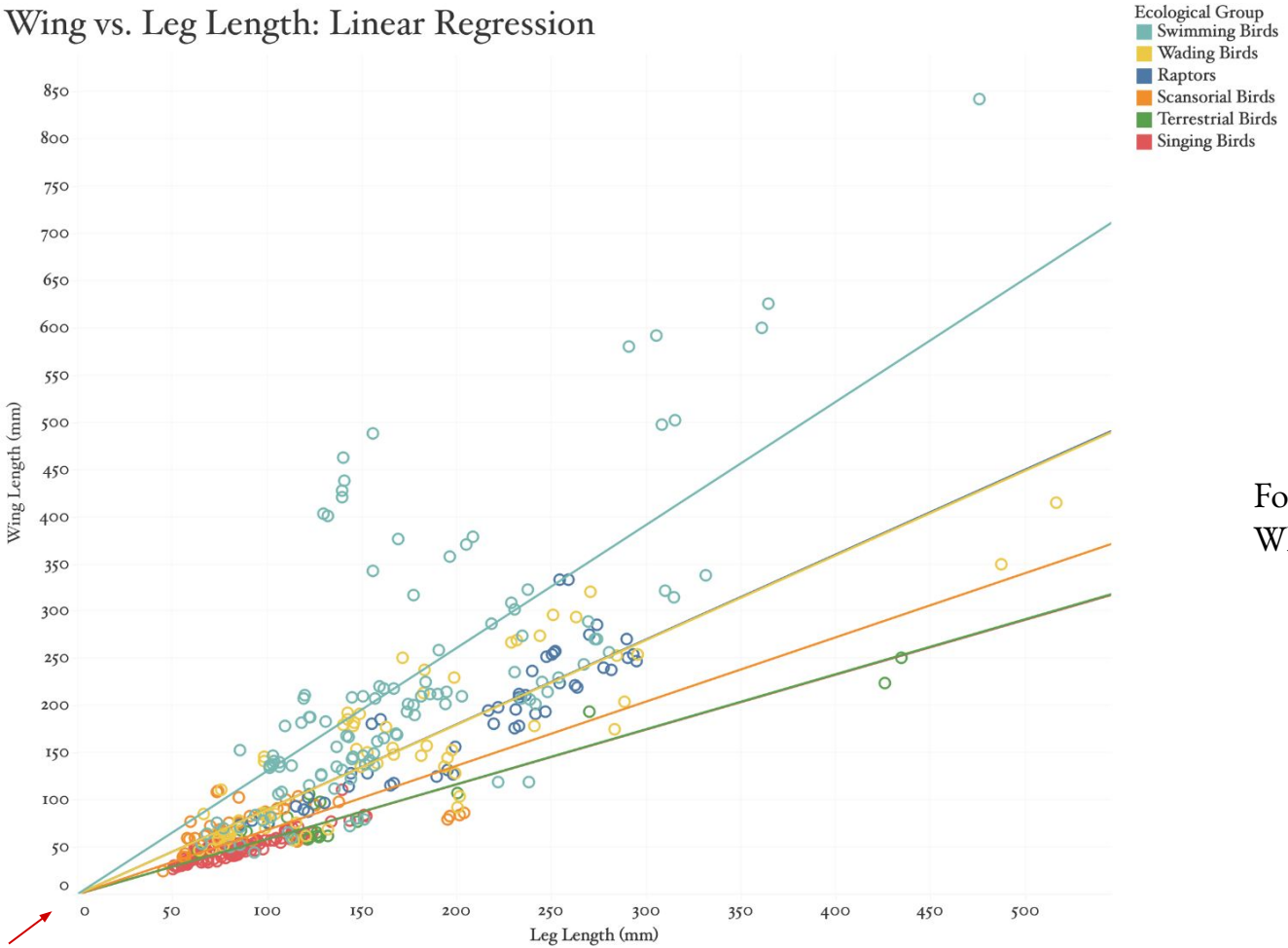
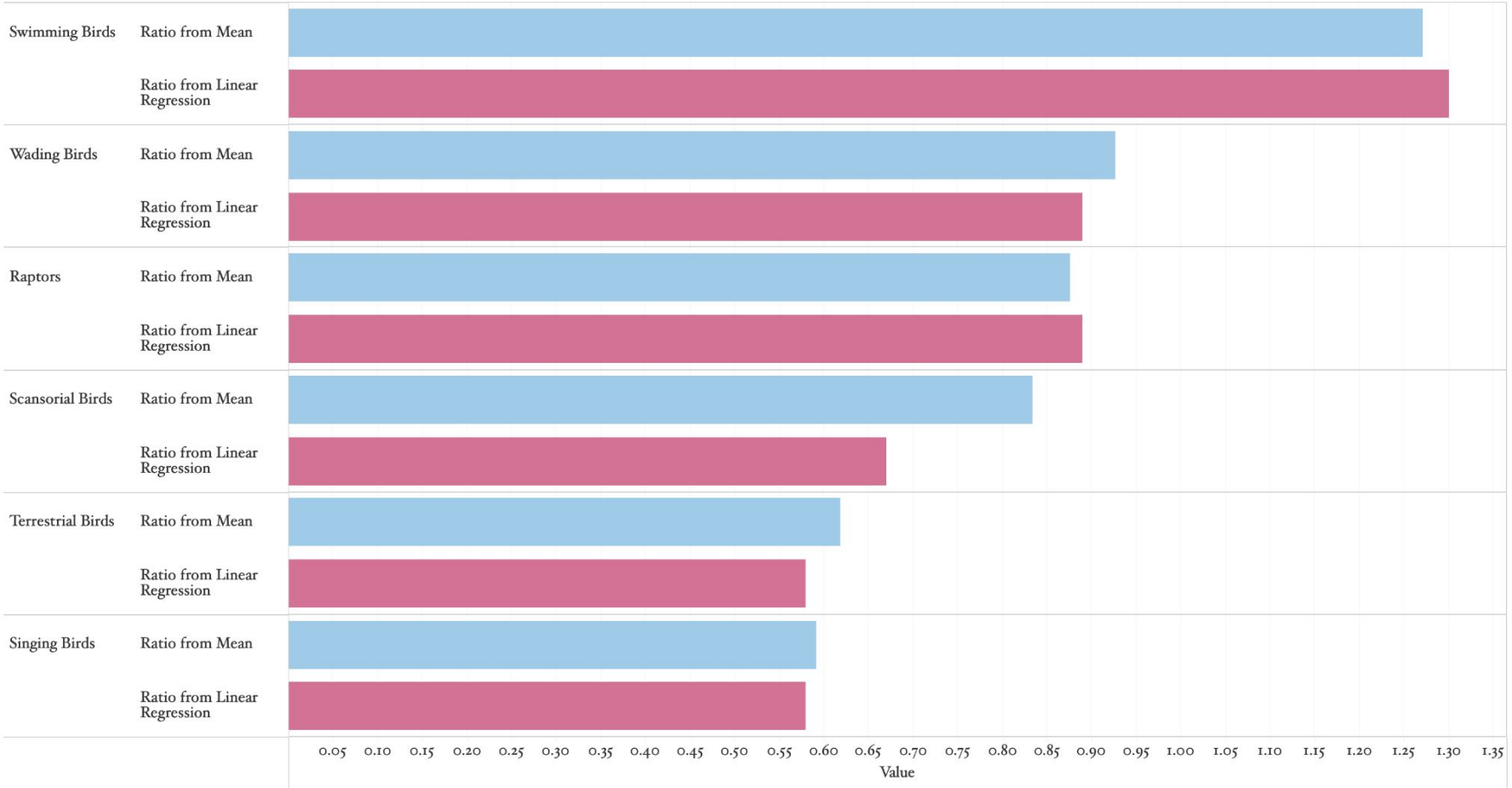


For further consideration:
When should y-intercept = 0?

Comparing Ratio Methods

Ecological Group	Ratio from Mean	Ratio from Linear Regression	Difference	R-Squared Value
Swimming Birds	1.27	1.30	-0.03	0.87
Wading Birds	0.93	0.89	0.04	0.94
Raptors	0.88	0.89	-0.01	0.98
Scansorial Birds	0.83	0.67	0.16	0.86
Terrestrial Birds	0.62	0.58	0.04	0.97
Singing Birds	0.59	0.58	0.01	0.98

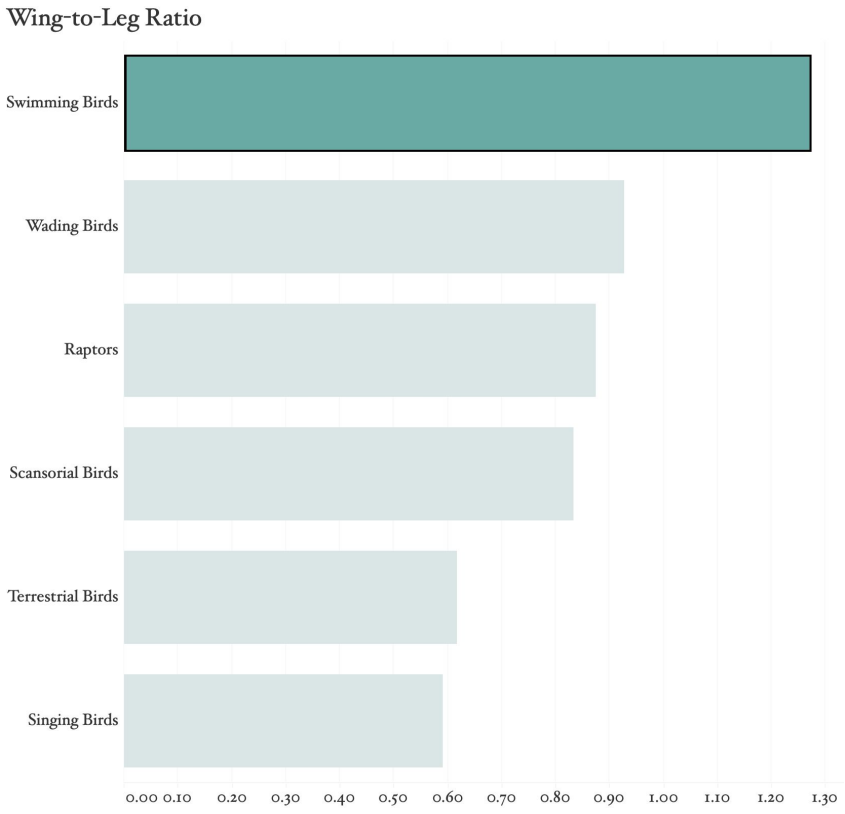
Comparing Ratio Methods: Bar Chart



Do the results make sense? What does the literature say?

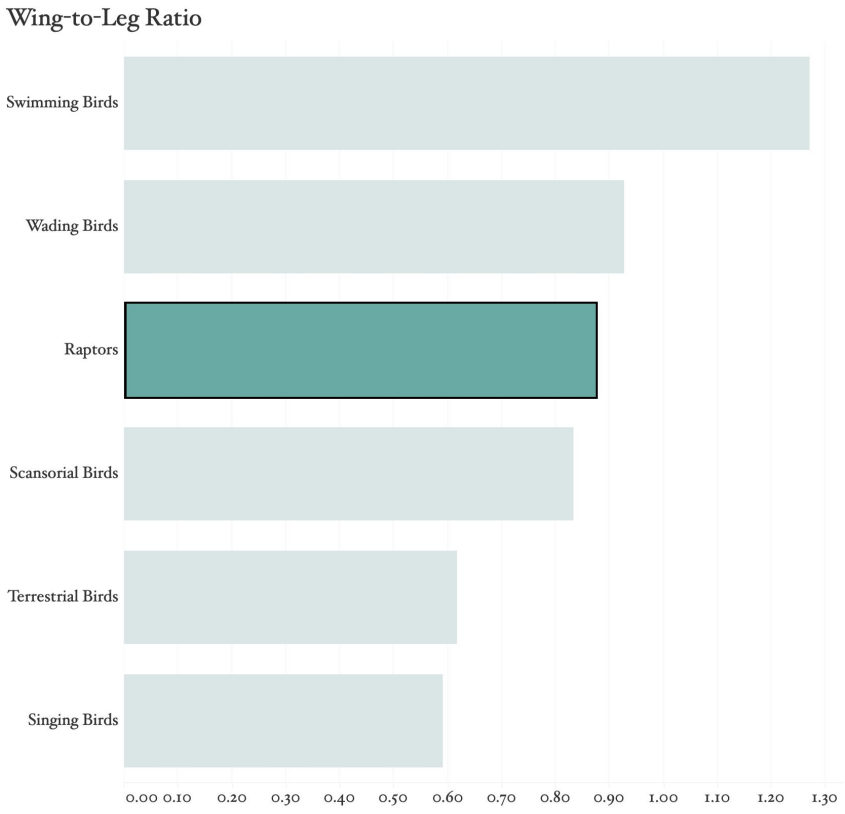
‘Functional correlation between habitat use and leg morphology in birds’ by Anna Zeffer, L. Christoffer Johansson, and Asa Marmebro (*Biological Journal of the Linnean Society*, 2003, 79, 461–484).

What Does the Literature Say?



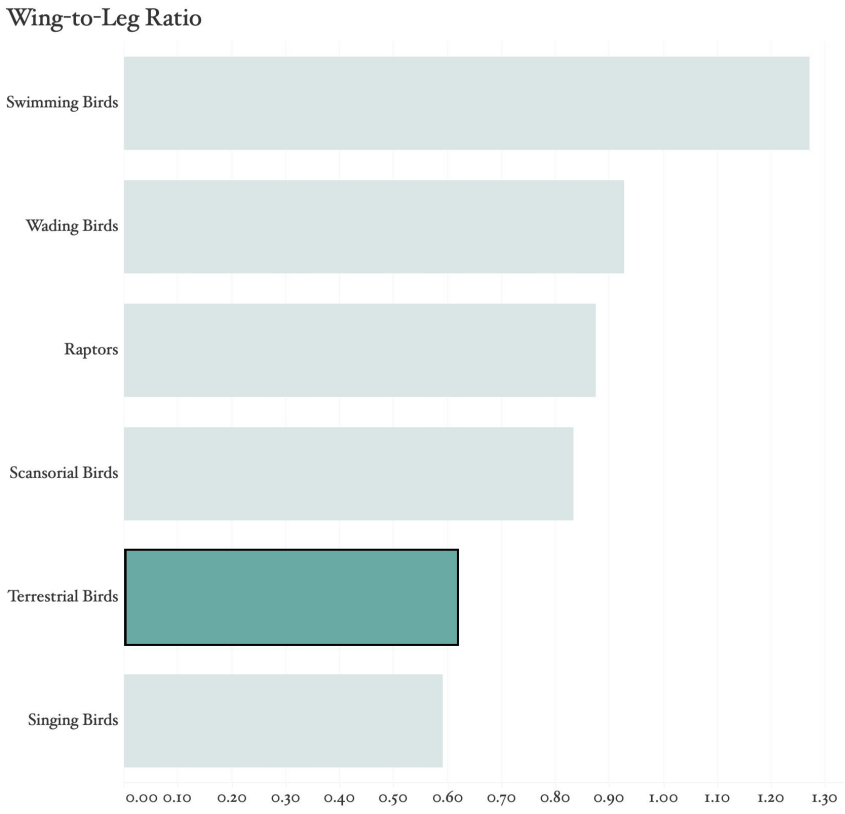
"Drag reduction is probably the most important common factor for swimming species. When birds swim it is primarily the tmt [tarsometatarsus] that generates the paddle motion of the feet. This locomotion mode should be favoured by short legs... so that disruption of the flow past the body is minimized as well as the drag from the legs and feet per se." (Zeffer et al.)

What Does the Literature Say?



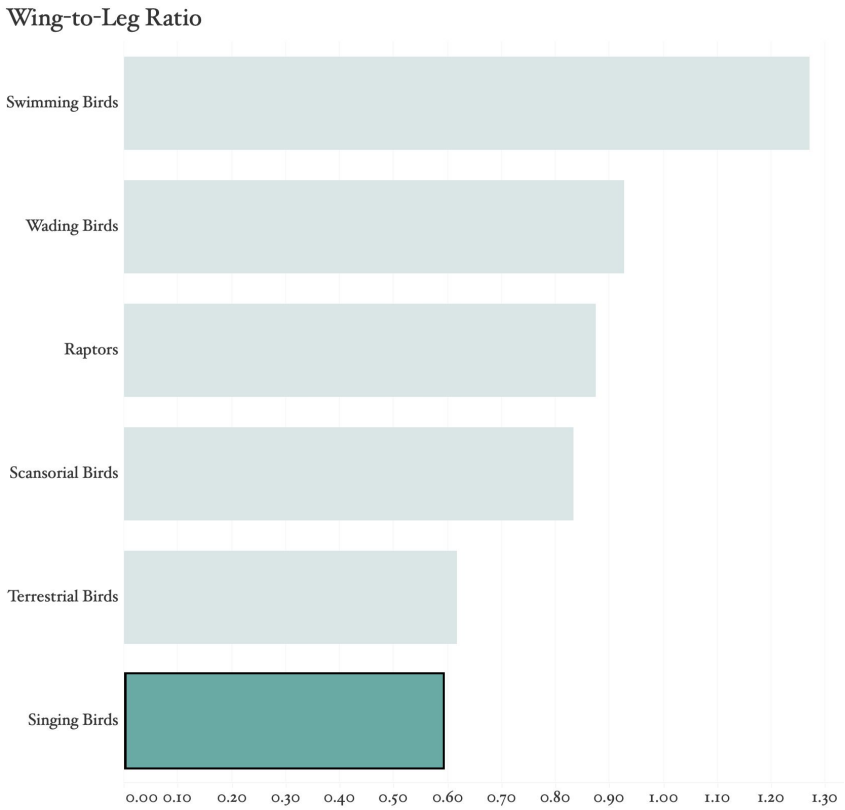
"It may be important for the predator to have visual contact with the prey until impact, in order to be able to adjust for escape movements. Long legs make it possible for the bird to stretch the feet forward and keep visual contact with the prey, whilst at the same time keeping visual cues for flight stability. Forward-stretched feet make it possible to **reach the prey with the feet first**, increasing the element of surprise and thus, probably, hunting success.... When making a strike, the birds often have high speed at the moment of impact. To reduce the instantaneous force required by the muscles... long legs may be expected to **cushion the shock to the bird.**" (Zeffer et al.)

What Does the Literature Say?



"These [ground species] use their legs for walking, running and/or hopping. We consider these species to be dependent on speed of locomotion, which is favoured by long legs (Engels, 1938; Bennett, 1996), i.e. a high leg length index. However, the lengths of the bones may be affected by different selection pressures." (Zeffer et al.)

What Does the Literature Say?



?

- Unclear why this group would have the longest legs relative to wing size.
- Most populous group in data set.
- If this group corresponds to passerines, it encompasses by far the largest order of birds, with a lot of diversity.

Return to Limitations

- Ecological group is not a standard taxon
- No species data
- Not an analysis of full skeletal structure
- Unable to take into account other physiological factors (e.g., mass)
- Unequal sample distribution
- I'm not a scientist
- Plenty of subtle differences, with subtle evolutionary reasons, within any taxon:
- "Making broad functional predictions is to simplify the variation found in nature. However, simplification is inevitable because of the lack of close knowledge of the ecology of the species and the effects of both ecology and physics on morphology." (Zeffer et al.)

Sources

Data: Birds' Bones and Living Habits (https://www.kaggle.com/datasets/zhangjuefei/birds-bones-and-living-habits).

Additional research: 'Functional correlation between habitat use and leg morphology in birds' by Anna Zeffer, L. Christoffer Johansson, and Asa Marmebro (*Biological Journal of the Linnean Society*, 2003, 79, 461–484).