Is island life turning birds into giants? An assessment of Foster's rule across all birds

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Introduction

A perplexing biological process occurs in island populations where the body sizes of animals tend to differ markedly from their mainland counterparts. The natural isolation of islands present unique conditions which leads to insular gigantism in small species, and insular dwarfism in large ones – a trend known as Foster's rule (Figure 1.). First observed in island mammals [1], birds present an interesting study opportunity due to their ability to disperse through flight.

Measurements such as bill size, wing length, tarsal length and body mass [2] have all served as stand-ins (but rarely in the same study). Using three different surrogates for overall size (body mass, body length, and wingspan), I compared the body sizes of island bird species to their mainland counter parts. My primary goal for this project was to examine the Foster's rule as it applies to all birds, first as a collective class and then by individual order (19 for mass, 18 for length, and 4 for wingspan). My secondary goal was to compile multiple large dataset with various biological information for future studies.

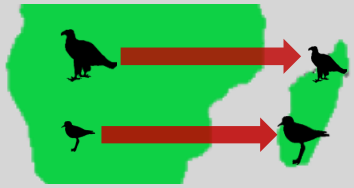


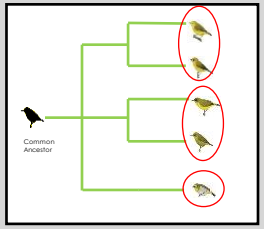
Fig. 1 – On islands, large mainland species often undergo insular dwarfism. Likewise, smaller mainland species transition to larger forms through insular gigantism.

Methods

1. Data Collection:
i. Determine land status of birds using IUCN Redlist [3].
ii. Acquire body masses available from the Wilman et al. dataset [4]. Body lengths and wingspans taken from Birdlife [5].

2. Create a Phylogeny:
i. Generate 1000 phylogenic trees using Birdtree [6]
ii. Create a maximum clade credibility tree using Treeanotator [7].

3. Statistical Analysis:
i. Assess using phylogenetic generalized least squares (PGLS) analysis in R Studio [8].



What is a phylogeny and why do we use them?

- **Phylogeny** - a hypothesis about the evolutionary relationship between species
- includes the last common ancestor and all descendants
- Allows for PGLS analysis to account for shared ancestry – eliminates independence for related groups

Major Results

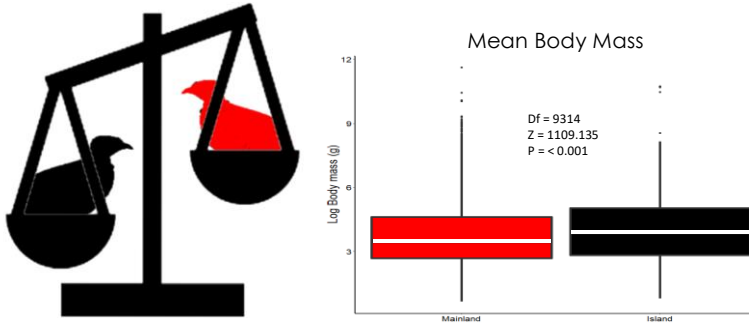


Fig. 2 – A PGLS analysis of birds as a whole (n = 9, 316) found a significant difference between the average body masses of birds on islands versus their mainland counterparts. Birds appear to be getting larger (by body mass) on islands, indicating a directional change towards insular gigantism.

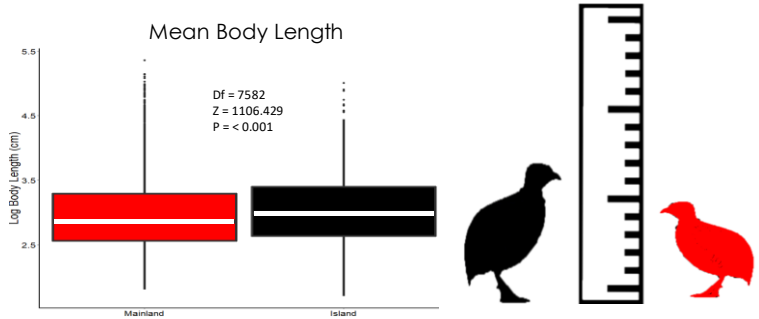


Fig. 3 – A second PGLS analysis of birds as a whole (n = 7, 584) also found a significant difference between the average body lengths of birds on islands versus their mainland counterparts. Again, birds appear to be getting larger (by body length) on islands, indicating a directional change towards insular gigantism.

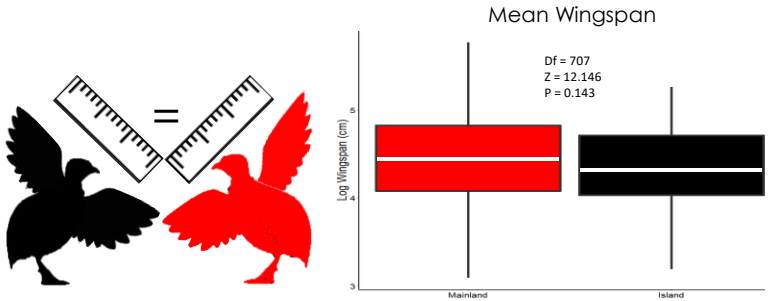


Fig. 4 – The final PGLS analysis for birds as a class (n = 709) failed to find any significant difference between the average wingspans of birds on islands versus those on mainland habitats. Land status (island or mainland) does not appear to be a predictor of wingspan in birds

Discussion

There is strong support for the application of Foster's rule in birds, depending on the surrogate used for body size. I found that land status (island or mainland) is a predictor of both body mass and body length, with island species having greater mean measurements than would be expected by chance alone. My results also show that Foster's rule is fairly widespread in birds as a whole with evolutionary associations having an important but seemingly reduced role. For most bird groups, Foster's rule appears to be acting on taxonomic levels smaller than order. Overall, island birds appear to be both more massive and have an increased body length compared to their mainland relatives.

When the data was broken down to the level of order, most did not meet the level of significance for any body measurement. Those that did trended in a direction consistent with what I would expect from groups following Foster's rule. The following orders (Table 1) showed significant differences in at least one body measurement.

Table 1. Individual orders with significant results where gray = mean body mass, red = mean body length, and black = mean wingspan.

Order	n (island/mainland)	df	Z (test statistic)	P	Diff on islands
Anseriformes	150(16/134)	148	179.011	<0.001	decrease
Galliformes	272(49/223)	270	16.901	0.009	increase
Piciformes	380(39/341)	378	17.617	0.006	increase
Anseriformes	127(16/111)	125	147.049	<0.001	decrease
Pelecaniformes	96(7/89)	94	14.239	0.042	decrease
Piciformes	319(24/295)	317	136.190	<0.001	increase
Strigiformes	166(57/109)	164	110.960	0.001	increase
Accipitriformes	203(49/154)	201	19.148	0.003	decrease
Charadriiformes	199(21/178)	197	14.245	0.041	decrease

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References

1. Foster J. 1964. Evolution of mammals on islands. Nature, 202(4929), 234-235. doi:10.1038/202234a0
2. Cleg Owens P. 2002. The "island rule" in birds: medium body size and its ecological explanation. Proceedings of the Royal Society B: Biological Sciences, 269(1498)(5 &), 1359–1365. doi:10.1098/rspb.2002.2024
3. IUCN. 2019. The IUCN Red List of Threatened Species. Version 2019-2. R core Team. Retrieved from https://www.iucnredlist.org
4. Wilman H., Belmaker J., Simpson J., de la Rosa C., Riv adeneira M., Jetz W. 2014. EltonTrails 1.0: Species-level foraging attributes of the world's birds and mammals. Ecology, 95(7), 2027–2027. doi:10.1890/13-1917.1
5. del Hoyo J., Elliott A., Sargatal J., Christie D. A. & Kirwan G. (eds.). 2019. Handbook of the Birds of the World Alive. Lynx Edicions, Barcelona. Retrieved from http://www.hbw.com/
6. BirdLife International and Handbook of the Birds of the World. 2018. Bird species distribution maps of the world. Version 2018.1. Available at http://datazone.birdlife.org/species/requestdis.
7. Rambaut A., & Drummond A. 2018. TreeAnnotator v 1.10.1: MCMC Output analysis. Retriev ed from http://beast.community/.
8. RStudio Team. 2016. RStudio: Integrated Development for R. RStudio, Inc. Inc. Boston, MA. Retrieved from https://www.rstudio.com/.