PHOENICULUS DAMARENSIS - P. PURPUREUS LATITUDINAL AS WELL AS LONGITUDINAL GRADIENTS IN MANTLE IRIDOSOME DIAMETERS WHEN CONTROLLING FOR BODY MASS

M. IAN COOPER

Department of Botany & Zoology, University of Stellenbosch, Matieland 7602, South Africa.

Abstract. **A latitudinal and longitudinal gradient was proposed in microscopic differences in green and violet woodhoopoe mantle iridosome diameters of mantle feathers with body mass. Outer iridophore diameters from Green Woodhoopoe P. p. purpureus barbules (0.22± 0.03 µm, n = 244) recorded at Morgan Bay were smaller than those from violet barbules (0.28 ± 0.04 µm, n =248) recorded in Namibia. A latitudinal gradient demonstrated a strong correlation with outer diameters over mass (Kendall's τ=0.64051262, Z score=80000, n=6, p=0)). When the outer diameters were divided by body mass the correlation with longitude was also significant (Kendall's τ=0.64051262, Z score=-80000, n=6, p=0). This study examined woodhoopoes mantles which may have consequences for energy expenditures.**

Keywords: **mass; latitude, longitude, microscopy, *Phoeniculus*, woodhoopoe.**

I. INTRODUCTION

There is an ecogeographical rule which states within a species of endotherms, more heavily pigmented forms are found in more humid environments near the equator [9]. It was first remarked upon this phenomenon in 1833 in a review of covariation of climate and avian plumage color. The Namibian Violet Woodhoopoe P. d. damarensis is an arid near-endemic with a partially resolved taxonomic status [3, 5, 2, 12]. It is closely related to the Green Woodhoopoe Phoeniculus purpureus yet differs in mass and mantle feather colouration [3, 4, 7, 10]. Here I provide some resolution to the ecogeographical status of the Violet Woodhoopoe P. damarensis in comparison with the Green Woodhoopoe P. purpureus, using microscopic details of mantle feathers across latitude as well as longitude.

II. MATERIALS AND METHODS

Mantle feathers were sampled from netted live Violet (Namibia: Hobatere and Omaruru; n = 9) and a dead Green Woodhoopoe (Morgan Bay; n = 1) in 1999. Mantle feathers were soaked for 30 minin 0.25M NaOH, followed by 2 hours in formic acid: EtOH (2:3 v/v) and 3 days in 15% (v/v) Spurr's resin in propylene oxide. They were then embedded in Spurr's resin. Both transverse and longitudinal sections of the barbules were cut, revealing that the iridophores of both species were hollow prolate cylinders. Iridophore cylinder widths were measured and correlated with latitudes and longitudes using the Kendall Correlation Coefficient Calculator (https://www.gigacalculator.com/calculators/correlation-coefficient-calculator.php).
Measurements of the outer iridosome diameter of Green feathers from the Morgan Bay bird were compared with those from a Hobatere bird and an Omaruru bird. Next I controlled for by mass and produced a correlation of mean outer iridosome diameters divided by body mass against latitude and longitude (here). Both localities had a UltraViolet Index of 0, similar mean annual temperatures (22 °C).

III. RESULTS

Mantle feathers and iridophores from Namibian Violet Woodhoopoe P. damarensis and Green Woodhoopoe P. p. purpureus vary according to latitude (Figure 1) and longitude (Figure 2). Birds identified as P. d.damarensis had predominantly violet mantles. The difference between woodhoopoe species is a strong correlation between outer diameter and latitude (Kendall's τ=0.64051262, Z score=80000, n=6, p=0) as well as longitude (Kendall's τ=0.64051262, Z score=-80000, n=6, p=0), when the outer diameters were divided by body mass. Outer diameters did (not) correlate with mean body mass (r=0.40824829, Z score=20000, n=4, p=0).

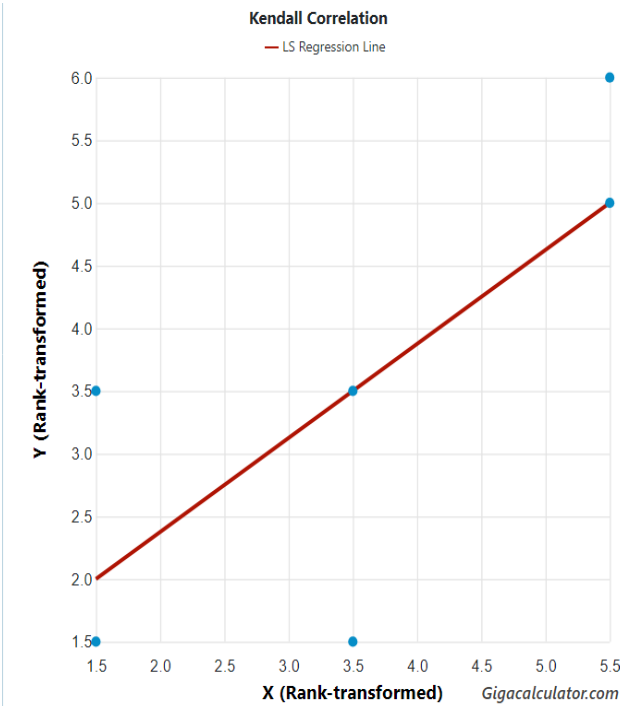

Figure 1. Correlation between iridosome outer diameter (0.22 versus 0.28) (y-axis) and latitude (x-axis) of woodhoopoe mantle feathers from Morgan Bay -32.7053S), Hobatere (-19.354066S), and Omaruru (-21.418501S) after controlling for body mass.

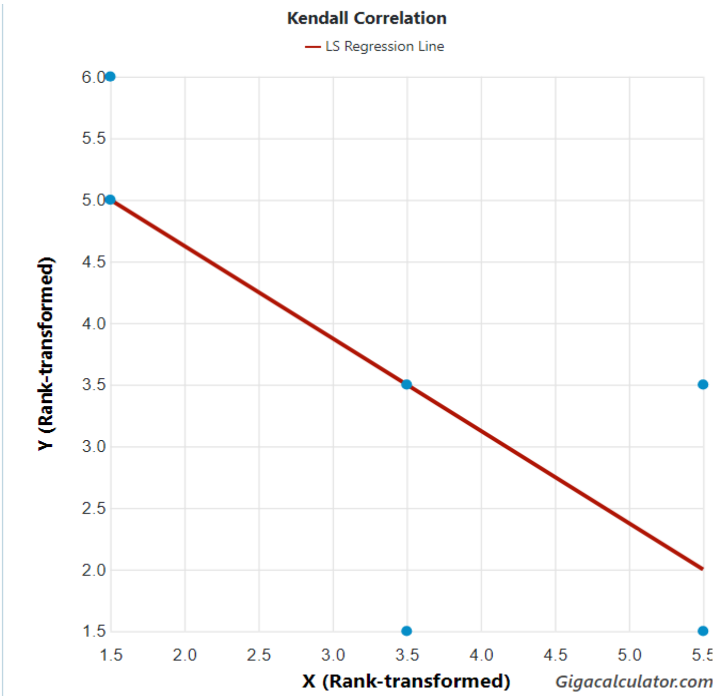

Figure 2. Correlation between iridosome outer diameter (0.22 versus 0.28) (y-axis) and longitude (x-axis) of woodhoopoe mantle feathers from Morgan Bay (28.3397E), Hobatere (14.404520E), and Omaruru (15.955660E) after controlling for body mass.

IV. DISCUSSION

Examination of mantle feathers from woodhoopoes suggests a clinal variation [4]. A simple model of latitudinal and longitudinal gradients can account for differences between iridophore diameters, differences that are enough to distinguish green from violet woodhoopoes. This study reveals woodhoopoes mantles have consequences for energy expenditure [7]. The results support a complex version of the biological rule [5, 9, 11]. This supports the results found in Australasian song bird clades [8]. It is also consistent with darker birds being larger than lighter birds [1, 4, 5]. Closer examination of rainfall and temperature and a comparison among woodhoopoes from different latitudes helps to reconcile the complex and simple biological rules [4, 6]. A cursory examination showed mean annual temperatures to be nearly identical so differences in precipitation gradient as predicted in the original simple rule are probably causal [9].

V. CONCLUSION

Examination of mantle feathers from woodhoopoes suggests latitudinal and longitudinal variation of the outer iridosome diameters consistent with the biological rule.

REFERENCES

[1] Carballo, L., Delhey, K., Valcu, M., Kempenaers, B. (2020). Body size and climate as predictors of plumage colouration and sexual dichromatism in parrots. Journal of Evolutionary Biology 33(11): 1543-1557.

[2] Cooper, M.I. (2022). PHENOTYPIC STATUS OF THE NAMIBIAN VIOLET WOODHOOPOEPHOENICULUS DAMARENSIS AS DETERMINED BY MASS. Universe International Journal ofInterdisciplinary Research 2(9): 7-8.

[3] Cooper, M.I., Cunningham, M., Cherry, M.I. (2001). Taxonomic status of the Namibian Violet Woodhoopoe *Phoeniculus damarensis* as determined by mitochondrial DNA. Ibis 143(3): 572-579.

[4] Cooper, M.I., Sewell, B.T., Jaffer, M.A. (2017). Differences between Violet and Green Woodhoopoe mantle feathers. Biodiversity Observations 8.46: 1-2.

[5] Cooper, M. I. 2022. PHOENICULUS DAMARENSIS - P. PURPUREUS LATITUDINAL GRADIENT IN MANTLE IRIDOSOME DIAMETERS. Universe International Journal of Interdisciplinary Research 2(11): 114-117.

[6] Cunningham, M., Cherry, M.I. (2005). Seeing the woodhoopoe for the trees: a response to Simmons et al. (2005). Ibis 147(1): 225–227.

[7] Delhey, K., Dale, J., Valcu, M., Kempenaers, B. (2019). Reconciling ecogeographical rules: rainfall and temperature predict global colour variation in the largest bird radiation. Ecology Letters 22: 726–736.

[8] DuPlessis, M.A., Williams, J.B. (1994). Communal cavity roosting in green woodhoopoes: consequences for energy expenditure and the seasonal pattern of mortality. The Auk 111(2): 292-299.

[9] Friedman, N.R., Remeš, V. (2017). Ecogeographical gradients in plumage coloration among Australasian songbird clades. Global Ecology and Biogeography 26: 261-274.

[10] Gloger, C.W.L. (1833). §. 5. Abänderungsweise der einzelnen, einer Veränderung durch das Klimaunterworfenen Farben. Das Abändern der Vögel durch Einfluss des Klimas [The Evolution of Birds Through the Impact of Climate] (in German). Breslau: August Schulz. 11–24.

[11] Ligon, J.D., Kirwan, G.M. (2020). Violet Woodhoopoe (Phoeniculus damarensis), version 1.0. In del Hoyo, J., Elliott, A., Sargatal, J., Christie, D. A. & de Juana, E. (eds) Birds of the World. Cornell Labof Ornithology, Ithaca, NY, USA.

[12] Marcondes, R. (2021). Testing the simple and complex versions of Gloger's rule in the Variable Ant shrike (Thamnophilus caerulescens, Thamnophilidae). Dryad, Dataset.

[13] Simmons, R.E., du Plessis, M.A., Hedderson, T.A.J. (2005). Seeing the woodhoopoe for the trees: should we abandon Namibia's Violet Woodhoopoe *Phoeniculus damarensis* as a species? Ibis147(1): 222-224