The effect of food restriction on feather and wing quality in the Rhinoceros Auklet (*Cerorhinca monocerata*)

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Introduction

Seabirds and stress

- Seabirds are long-lived organisms with low fecundity and high adult survival rates (Vermeer and Cullen, 1979; Takenaka et al. 2005)
- During food shortages, parents reduce provisioning to chicks. Nutritional stress during development may affect survival and reproductive fitness of individuals (Pravosudov and Kitaysky, 2006; Takenaka et al., 2005; Sears and Hatch, 2008)
- Here we test the effects of nutritional limitation on feather development and quality in the rhinoceros auklet. We focus on feather development for the following reasons:
  - Feather production is costly and might be affected by allocation of limited resources during food shortages (DesRochers et al., 2009; Takenaka et al., 2005; Benowitz-Fredericks et al., 2006; Sears and Hatch, 2008)
  - Fluctuating feather asymmetry, coloration and UV reflectance indicates developmental instability and serve as a badge of individual quality (Hill, G.E and McGraw, K. J. 2006; Pravosudov and Kitaysky, 2006)

Hypothesis

- Food restriction during neonatal development impairs feather and wing development and will result in:

1) Reduced wing length

2) Increased fluctuating asymmetry (e.g. difference between individual's left and right wing area)

3) Lower barbule density of feathers

4) Lower UV reflectance in feathers – a signal of a lower quality individual visible to other birds

Study subjects

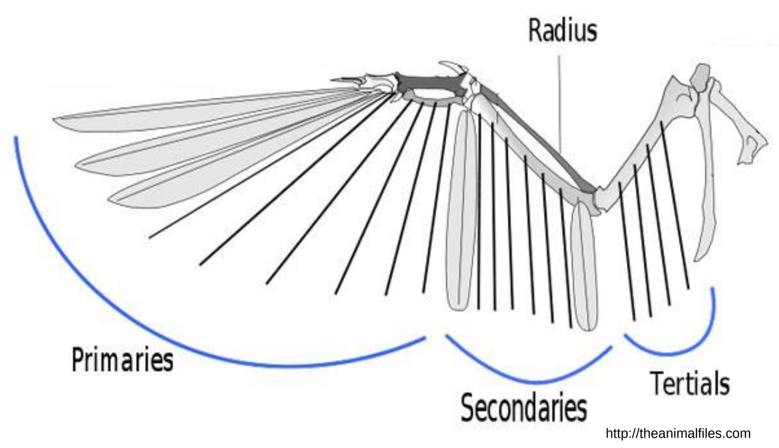
12 euthanized rhinoceros auklet chicks (Sears and Hatch 2008)

- 6 individuals fed ad libitum
- 6 individuals raised under food restriction (50% of ad libitum)

Methods

1) Wing length

Right and left wing length (from radius to 10th primary feather) were measured for each individual. Wing lengths were measured to the nearest millimeter using calipers.



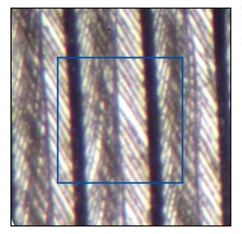
2) Wing asymmetry

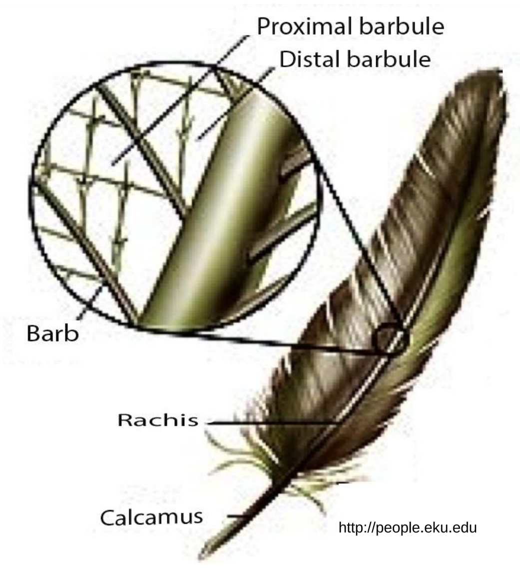
Surface areas of right and left wings were compared. Each wing was traced on paper, cut out, and converted into weight to determine surface area.

3) Feather density

Digital camera mounted on microscope was used to take images of barbules. Number of barbules within 0.25mm^2 were counted.

- 1 Back feather
- 1 Primary feather from each wing
- 1 Secondary feather from each wing





4) UV reflectance

Ocean Optics spectrometer was used to measure reflectance of wing coverts and primary feathers between wavelength of 350nm and 700nm. Brightness and UV chroma were calculated for statistical analysis. Average reflectance across wavelength (350 – 700nm) was calculated to determine brightness. UV chroma was calculated as sum of reflectance between 350-400nm divided by sum of reflectance between 350-700nm.

Results

1) Wing length

Both treatment groups had similar wing length. (t=-1.00, p=0.1717; Fig. 1).

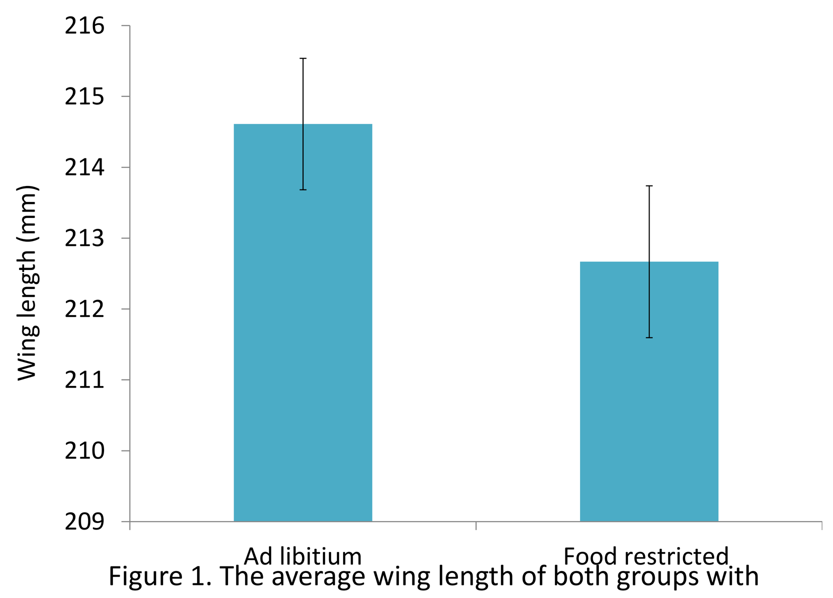


Figure 1. The average wing length of both groups with standard error bars (Ad libitum: ±0.927; Food restricted: ±1.071).

2) Wing asymmetry

We found no evidence that wing asymmetry occurred in food restriction compared to ad libitum (t=-1.372, p=0.100; Fig. 2).

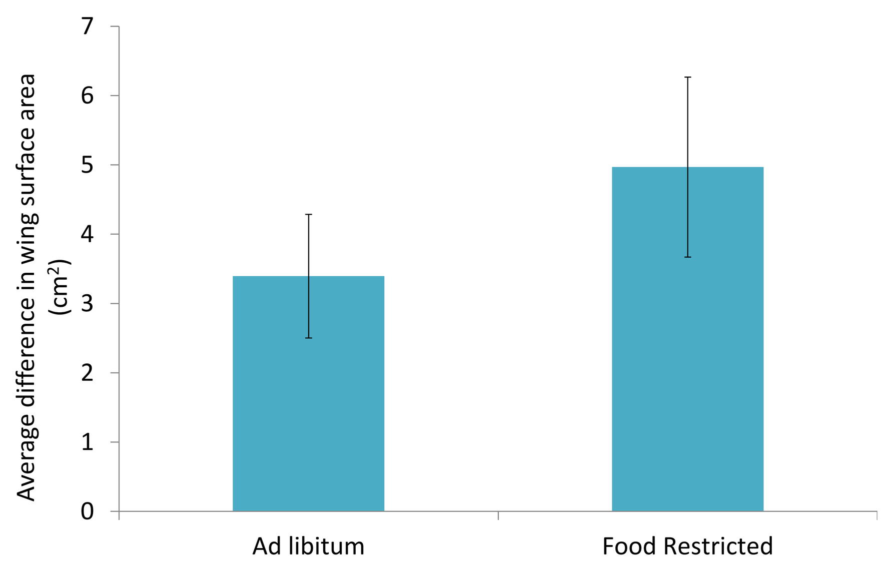


Figure 2. The average difference between right and left wing surface area within an individual with standard error bars (Ad libitum: ±0.892; Food restricted: ±1.298).

3) Feather density

Food restricted chicks had fewer barbules in primary feathers, but not secondary or back feathers (Bonferroni corrected α=0.0166. Primary: t=1.86, p=0.0005. Secondary: t=2.273, p=0.0245. Back: t=0.80, p=0.057, Fig. 3).

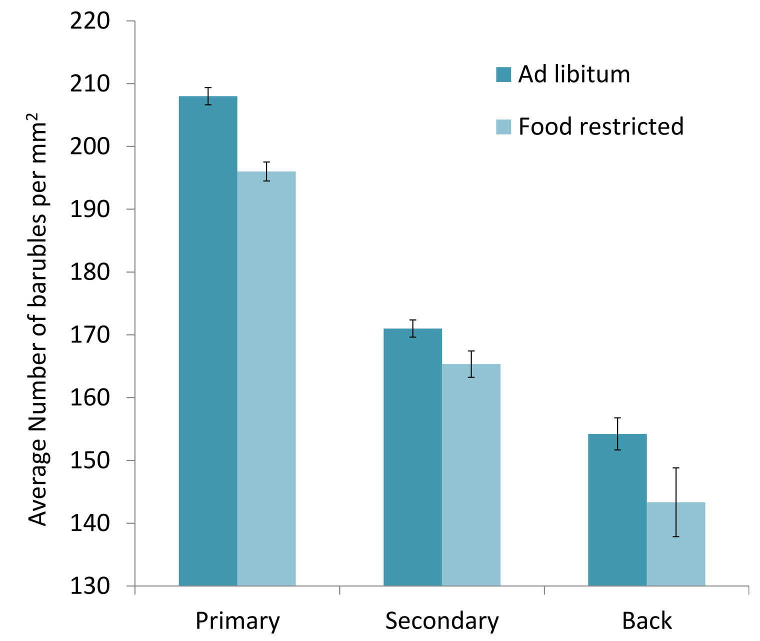


Figure 3. Bars represent average number of barbules within 1 mm^2 in each treatment, and they are estimated from number of barbules within 0.25 mm^2. Food restriction resulted in lower barbule density for primary feather. Standard error bars are used (Primary: Ad libitum:±1.377; Food restricted:± 1.520. Secondray: Adlibitum ±1.364; Food restricted: ±2.087. Back: Ad libitum:±2.544; Food restricted: ±5.484).

4) UV reflectance

Both groups had similar reflectance in primary feathers and wing coverts (Brightness: primary; t=-0.168, p= 0.435; wing covert: t=0.453, p=0.330. UV chroma: Primay: t=-0.357, p=0.365; wing covert t=-1.040, p=0.1612; Fig. 4).

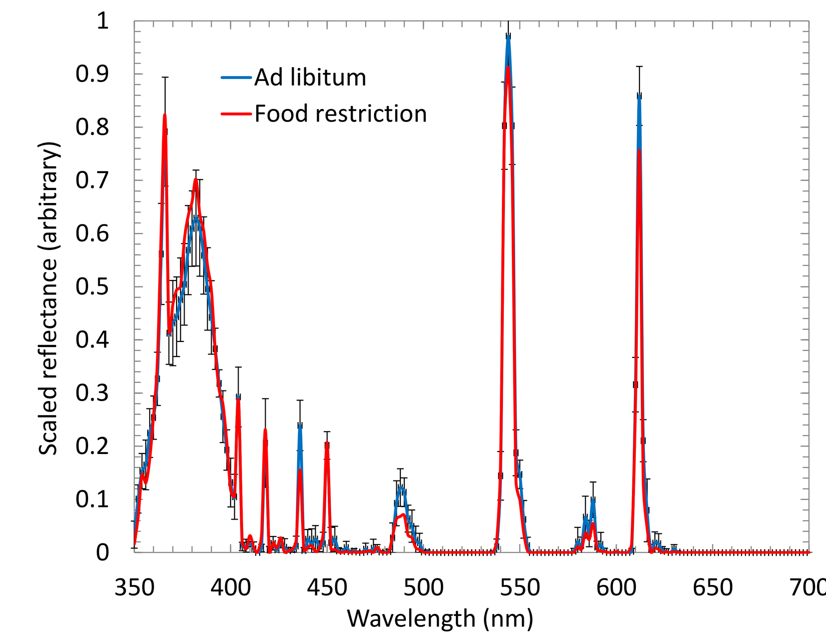


Figure 4. The average reflectance of wing coverts in ad libitum and food restricted individuals at wavelength of 350nm – 700nm with standard error bars of ad libitum. The data is scaled to maximum spectrum reflectance of 1. The peaks shows reflectance of light at a particular wavelength. Both groups had peaks in the UV spectrum (350 - 400nm) which shows that wing coverts reflect UV light.

Discussions and Conclusion

- Our results suggest that food restriction during development did not affect wing length or symmetry. This indicates that, when food limited, chicks preferentially allocate resources to wing development.
- Food limited chicks, however, had lower barbule density in their primary feathers, an important feather for flight and wing-propelled diving. Growing this feather may take larger amounts of resources.
- We conclude that food restricted chicks were unable to fully compensate for reduced resources and carried the signal of neonatal food restriction in the lower barbule density of their primary feathers. Insufficient flight feather growth may result in a survival disadvantage during critical post-fledging period; further tests on the consequences of impaired flight feathers are necessary.

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References

1) Benowitz-Fredericks, M. T. Z., Kitaysky, A. S., & Thompson, C. W. (2006). Growht and allocation in captive common murre (*uria aalge*) chicks. The American Ornithologists' Union, 123, 722-734.
2) DesRochers, D.W., Reed, J.M., Awerman, J., Kluge J.A., Wilkinson, J., Griethuijsen L.I. Aman,J., and Romero, M.L. (2009). Exogenous and endogenous corticosterone alter feather quality. Comparative Biochemistry Physiology Part A. 152:46-52
3) Hill, G.E and McGraw, K. J. (2006). Bird coloration mechanisms and measurements. Cambridge: Harvard University Press.
4) Kitaysky, A.S, Kitaysikia, A.V, Piatto J.F, and Wingfield, J.C. (2003). Benefit and cost of increased levels of corticosterone in seabird chicks. Hormone Behavior 43:143-149
5) Pravosudov, V.P., and Kitaysky, A.S. (2006). Effects of nutritional restrictions during post-hatching development on adrenocortical function in western scrub-jays (*Aphelocoma californica*). General and comparative endocrinology 145:25-31
6) Romero, L.M., Strochlic, D., and Wingfield J.C. (2005). Corticosterone inhibits feather growth: Potential mechanism explaining seasonal down regulation of corticosterone during molt. Comparative biochemistry and physiology, Part A 142: 65-73
7) Sears, J. and Hatch, S.A. (2008). Rhinoceros Auklet development responses to food limitation: an experimental study. The condor 110: 709-717
8) Strochlic, D. E., and Romero, L. M. (2008). The effects of chronic psychological and physical stress on feather replacement in European starlings (*Sturnus vulgaris*). Comparative Biochemistry and Physiology, Part A 149: 68-79
9) Takenaka, M, Niizuma, Y, and Watanuki, Y. (2005). Resource allocation in fledglings of the rhinoceros auklet under different feeding conditions: an experiment manipulating meal size and frequency. Canadian Journal of Zoology 83: 1476–1485