

Everybody loves penguins! Relationships between bill and flipper length in three species of penguins from the Palmer Archipelago

Title: Everybody loves penguins! Relationships between bill and flipper length in three species of penguins from the Palmer Archipelago

Jennifer M.T. Magel¹*

1. Department of Forest & Conservation Sciences, University of British Columbia, Vancouver, Canada

*Corresponding Author

Email: jenn.magel@gmail.com

Data Availability: The data and code that support the findings of this study are openly available on GitHub at https://github.com/jmagel/BIOL548T_penguins.

Conflict of Interest statement

The author declares no conflicts of interest.

Abstract

Everyone loves penguins! Antarctica is amazing and its penguins are the coolest, so we decided to study those. We studied three species of penguins: Adelie (*Pygoscelis adeliae*), Chinstrap (*Pygoscelis antarcticus*), and Gentoo (*Pygoscelis papua*) from three islands in the Palmer Archipelago. How do the various measurements (e.g., bill length, flipper length) of penguins correlate to each other? We assumed that penguins with longer bills would also have longer flippers, otherwise they would be disproportionate. But we weren't sure, so we decided to check using a very useful dataset from the 'palmerpenguins' R package, which was collected at the Palmer Station in Antarctica. We found that there was, indeed, a positive relationship between bill and flipper length in all three species of penguin. While we were at it, we also decided to compare the body measurements of penguins of the same species from different islands. We found that ... This study provides valuable information on Antarctic penguins, which can maybe somehow be used to inform future research.

Keywords: penguins, Antarctica, Palmer Archipelago, Adelie penguin, Chinstrap penguin, Gentoo penguin, morphometrics

Introduction

Penguins are a favourite subject of study among biologists, on account of their adorable waddle and their mysterious nature as denizens of the largely undiscovered Antarctic continent (let us ignore, for a moment, the penguins that exist outside of Antarctica). Because so many people love penguins, they are well worth studying.

Understanding the relationships between morphometric variables (e.g., bill length and flipper length) in penguins can help us to discover many fascinating things about them. For example, bill length is known to be correlated with sex in both Chinstrap and Gentoo penguins (Lee et al. 2015). Therefore, we wanted to further explore the relationship between various morphometric variables in Antarctic penguin populations.

Methods

To examine the relationship between bill and flipper length in our three chosen species of penguins, we used data collected by Dr. Kristen Gorman and the Palmer Station, Antarctica LTER (Gorman et al. 2014). This dataset contains data on 344 individual penguins that were measured on three islands in the Palmer Archipelago, Antarctica (Biscoe, Dream, Torgerson) in the austral summers of 2007/08, 2008/09, and 2009/10. Data was accessed using the 'palmer-

penguins' R package (Horst et al. 2020a). Examination of differences in morphometrics for penguins from different islands was also accomplished using the 'palmerpenguins' dataset (Horst et al. 2020a).

We used R version 4.3.1 (R Core Team 2023) and the following R packages: cowplot v. 1.1.1 (Wilke 2020), flextable v. 0.9.3 (Gohel and Skintzos 2023), GGally v. 2.1.2 (Schloerke et al. 2021), grateful v. 0.2.0 (Francisco Rodríguez-Sánchez et al. 2023), palmerpenguins v. 0.1.1 (Horst et al. 2020b), rmarkdown v. 2.25 (Xie et al. 2018, 2020; Allaire et al. 2023), tidyverse v. 2.0.0 (Wickham et al. 2019).

Code for all statistical analyses are publicly available on GitHub (https://github.com/jmagel/BIOL548T_penguins).

Results

We observed a positive relationship between bill length and flipper length for all three species of penguins (Fig. 1). Gentoo and Chinstrap penguins had a similar range of bill lengths, but Gentoo penguins had longer flippers on average. Adelie and Chinstrap penguins had similar flipper lengths, but Chinstrap penguins had longer bills.

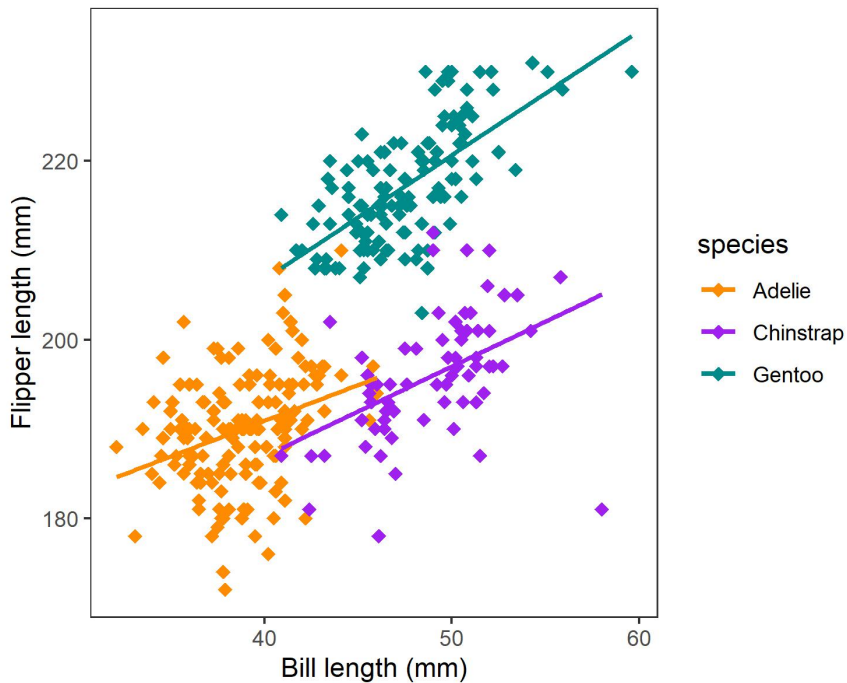


Figure 1. Relationship between bill length and flipper length in three species of *Pygoscelis* penguins from the Palmer Archipelago, Antarctica. Trend lines represent linear regressions fit using the 'geom_smooth()' function in ggplot.

We also found ...

[INSERT FIGURE 2]

Figure 2.

Discussion

Hooray for penguins! Our analysis demonstrates that penguins are amazing and that everyone should love and appreciate them. Penguins, which exhibit a beautiful relationship between bill and flipper lengths, can bring joy and happiness to our lives. Too bad they are so far away in Antarctica...

References

- Allaire, J., Xie, Y., Dervieux, C., McPherson, J., Luraschi, J., Ushey, K., Atkins, A., Wickham, H., Cheng, J., Chang, W., and Iannone, R. 2023. rmarkdown: Dynamic documents for r. Available from <https://github.com/rstudio/rmarkdown>.
- Francisco Rodríguez-Sánchez, Connor P. Jackson, and Shaurita D. Hutchins. 2023. grateful: Facilitate citation of r packages. Available from <https://github.com/Pakillo/grateful>.
- Gohel, D., and Skintzos, P. 2023. flextable: Functions for tabular reporting. Available from <https://CRAN.R-project.org/package=flextable>.
- Gorman, K.B., Williams, T.D., and Fraser, W.R. 2014. Ecological sexual dimorphism and environmental variability within a community of Antarctic penguins (Genus *Pygoscelis*). *PLoS ONE* 9(3): e90081. doi:10.1371/journal.pone.0090081.
- Horst, A.M., Hill, A.P., and Gorman, K.B. 2020a. palmerpenguins: Palmer Archipelago (Antarctica) penguin data. doi:10.5281/zenodo.3960218.
- Horst, A.M., Hill, A.P., and Gorman, K.B. 2020b. palmerpenguins: Palmer archipelago (antarctica) penguin data. doi:10.5281/zenodo.3960218.
- Lee, W.Y., Jung, J.-W., Han, Y.-D., Chung, H., and Kim, J.-H. 2015. A new sex determination method using morphological traits in adult chinstrap and gentoo penguins on King George Island, Antarctica. *Animal Cells and Systems* 19(2): 156–159. doi:10.1080/19768354.2014.1003600.
- R Core Team. 2023. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available from <https://www.R-project.org/>.
- Schloerke, B., Cook, D., Larmarange, J., Briatte, F., Marbach, M., Thoen, E., Elberg, A., and Crowley, J. 2021. GGally: Extension to “ggplot2.” Available from <https://CRAN.R-project.org/package=GGally>.
- Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L.D., François, R., Golemund, G., Hayes, A., Henry,

84 L., Hester, J., Kuhn, M., Pedersen, T.L., Miller, E., Bache, S.M., Müller, K., Ooms, J., Robinson, D., Seidel, D.P.,
85 Spinu, V., Takahashi, K., Vaughan, D., Wilke, C., Woo, K., and Yutani, H. 2019. Welcome to the tidyverse. *Journal*
86 *of Open Source Software* **4**(43): 1686. doi:10.21105/joss.01686.

87 Wilke, C.O. 2020. cowplot: Streamlined plot theme and plot annotations for “ggplot2.” Available from [https://CRAN.](https://CRAN.R-project.org/package=cowplot)
88 [R-project.org/package=cowplot](https://CRAN.R-project.org/package=cowplot).

89 Xie, Y., Allaire, J.J., and Golemund, G. 2018. *R markdown: The definitive guide*. Chapman; Hall/CRC, Boca Raton,
90 Florida. Available from <https://bookdown.org/yihui/rmarkdown>.

91 Xie, Y., Dervieux, C., and Riederer, E. 2020. *R markdown cookbook*. Chapman; Hall/CRC, Boca Raton, Florida.
92 Available from <https://bookdown.org/yihui/rmarkdown-cookbook>.