



Imaging Bat Wings

Images and Text by Zoe Miller

Introduction: General Bat Wing Anatomy

Unlike all other mammals, bats are capable of true and sustained flight. Even early ancestors were believed to be capable of flight. This is thanks to wings comprised of “a compliant membrane stretched across an articulated skeleton”¹. Belonging to the Order *Chiroptera* (which loosely translates to “wing hand”²), it is fitting for bat wings to structurally consist of fingers and skin. The membrane is comprised of two layers of skin³, and is made up of connective tissue, elastic fibers, nerves, and blood vessels⁴. When handling the subject, the wings were very fragile and felt similar to a very thin paper. The articulated skeleton consists of various joints and digits, just like any other mammal. Bats have shoulders, elbows, forearms, wrists, and four fingers plus a thumb, not dissimilar to humans.

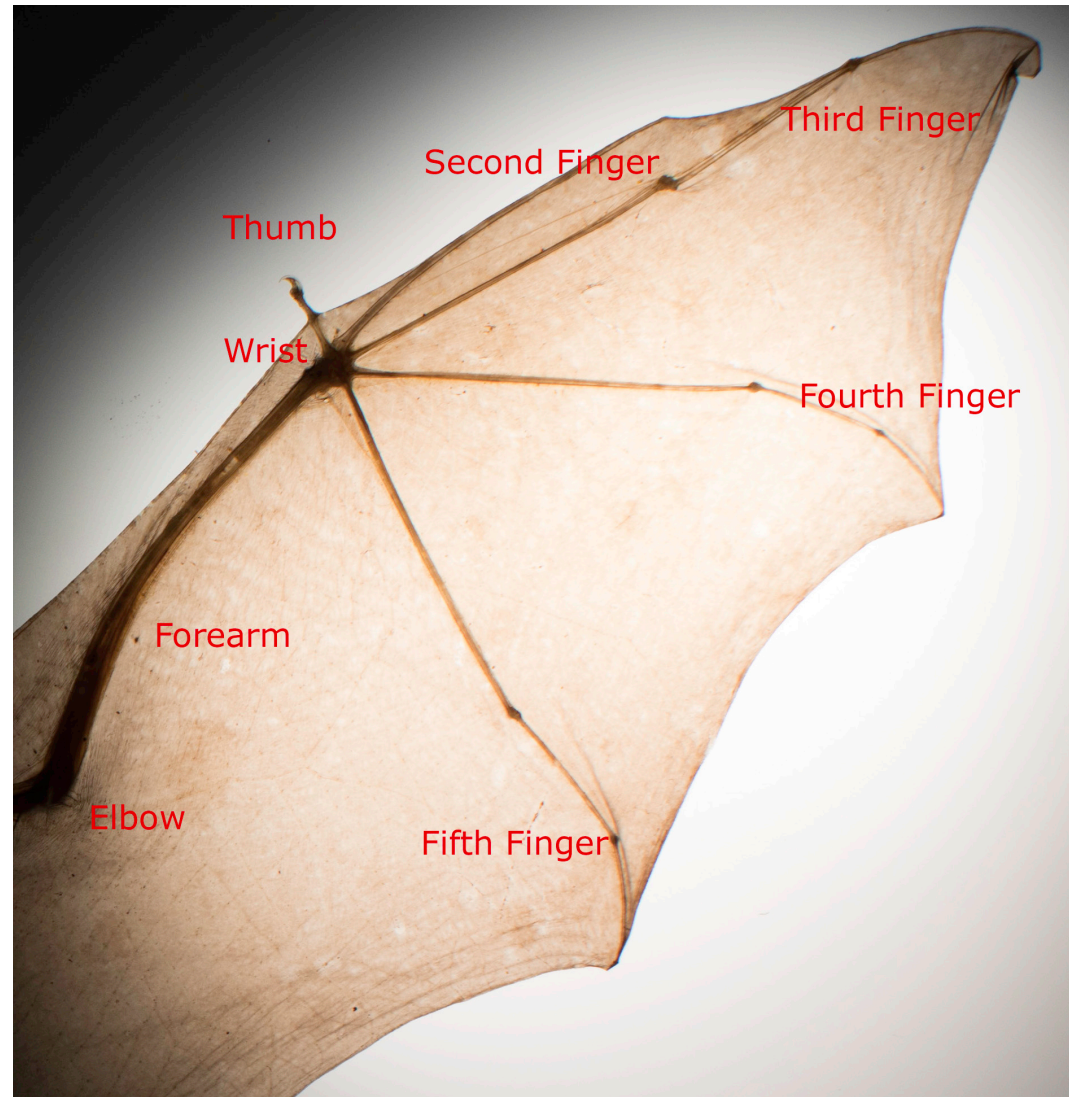


Figure 1. General skeletal anatomy of a bat. Not focus stacked; taken with 50 mm lens.

1 Bahlman, J. W., Price-Waldman, R.M., Lippe, H.W., Breuer, K.S., & Swartz, S.M. (2016). Simplifying a wing: diversity and functional consequences of digital joint reduction in bat wings. *Journal of Anatomy*, 229(1), 114-127. <https://doi.org/10.1111/joa.12457>.

2 Chiropteran. (n.d.). In *The Merriam-Webster.com Dictionary*. Retrieved from <https://www.merriam-webster.com/dictionary/chiropteran>.

3 Bat Wings. (n.d.). Retrieved from <https://www.kidzone.ws/animals/bats/facts2.htm>.

4 Wikipedia contributors. (2019). Bat. In *Wikipedia, The Free Encyclopedia*. Retrieved December 12, 2019, from <https://en.wikipedia.org/w/index.php?title=Bat&oldid=929663809>

While the general composition remains the same across species, the skeletal structures differ slightly. The number of wing joints differ, as well as the number of digits and the muscles present.

The two predominant categories of muscles found in the wings are flexor and extensor muscles¹. While many species have both categories of muscles, some lack flexor muscles. This distinction creates a changed flight pattern: instead of two muscles working in opposition of each other, bats lacking flexor muscles use "cyclical

^{1,2} Simplifying a wing: diversity and functional consequences of digital joint reduction in bat wings.

flexion-extension movements"² to mimic that of the two-muscled species.

More joints and muscles within the wing create greater flexibility, which translates to more possibilities in 3D wing shapes and increased flight precision. For bats with diets consisting predominately of insects, increased wing flexibility is important.

Figure 2. Full body of subject. Demonstrates paper-like wings. Taken with 50 mm lens. 52 image stack on Helicon Focus Pro. "Method B (depth map)" used with Radius: 8; Smoothing: 4.



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Commonly known as the Horsfield's leaf-nosed bat, *Hipposideros larvatus* is a species found across much of Asia¹. This specific subject came from Java, Indonesia. Disclaimer: the specimen was collected approximately 14 years ago and was not maintained in a laboratory.

Two techniques were implemented in the imaging of the subject. A lighting technique known as transillumination was implemented, as well as a capture technique called focus stacking. Due to the near-transparency of bat wings, the subject was a good candidate for this lighting technique that involves putting the subject on a translucent white acrylic sheet and lighting it from underneath with a fiber optic light source (as seen in *Figure 4*). This created a more diffused lighting, and allowed for light to pass through the subject.

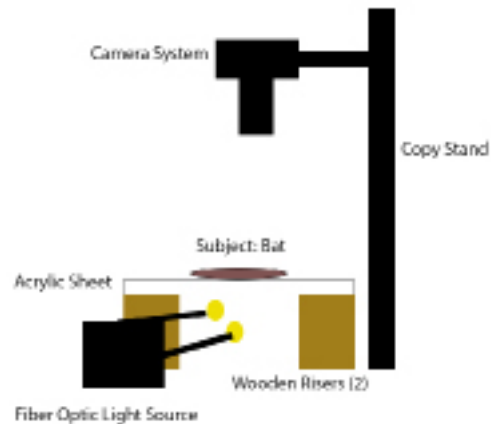
Focus stacking requires taking multiple images of the same subject with different areas in focus. The images are then taken into a software and "stacked" to create one image. This technique is very popular, especially in macro photography. The final stacked image appears to be a much sharper image than what could be achieved with a single shot. In macro photography especially, getting a sharp image with one shot is basically impossible.

Focus stacking can be very taxing to do precisely when trying to focus above 1X magnification- very slight changes in working distance can completely change what of the image is in focus. To help more precisely adjust small distances (as in microns at a time), a camera can be placed on a programmed motorized rail device. Specifically, a Cognisys, Inc. StackShot Automated Macro Rail was used to take these images. After capture, all of the images were brought into Helicon Focus 7 software to stack images automatically. Minor global adjustments and some spot removal were done to the generated TIFFs in Adobe Photoshop CC 2017.



Figure 3. Cognisys StackShot product. Macro rail and controller.

Image Credit: Cognisys StackShot Macro Rail Package Automated Stacking Image Capture for Stacking. (n.d.). In *Macro Dojo*. Retrieved from <https://www.macrodojo.com/product/cognisys-stackshot-macro-rail-package-automated-stacking-image-capture-stacking/>



(Left) Figure 4. Lighting diagram for transillumination including camera set up. A Canon Mark IV was used, as well as a 65 mm lens, ranging from magnifications of 1X-5X, and a 50 mm lens.

¹ Bates, P., Bumrungsri, S., Suyanto, A., Molur, S., & Srinivasulu, C. (2008). Horsfield's Leaf-nosed Bat. In *The IUCN Red List of Threatened Species*, 2008. Retrieved from <http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T10143A3173793.en>



Figure 5. Left wing of subject. Taken with 50 mm lens. Not focus stacked. Demonstrates transillumination.



Figure 6. Image of forearm, wrist, and five digits at 1X magnification. 23 image stack in Helicon Focus 7. "Method B" used at Radius: 8; Smoothing: 4.



Figure 7. Image of wrist and thumb with nail at 3X magnification. 31 image stack using "Method B", Radius: 3; Smoothing 4.



Figure 8. Foot with five digits at 3X magnification. 24 image stack using "Method B", Radius: 8; Smoothing: 4.

Additional Resources

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About the Author

Zoe Miller is a third-year Photographic Sciences student at Rochester Institute of Technology. She concentrates in Biomedical Photographic Communications, and minors in Mathematics.

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