Comment on "Narrow Primary Feather Rachises in *Confuciusornis* and *Archaeopteryx* Suggest Poor Flight Ability"

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Nudds and Dyke (Reports, 14 May 2010, p. 887) compared the rachis diameters of the primary feathers of *Archaeopteryx* and *Confuciusornis* to those of modern birds and found that the primary feathers of these two basal birds were too weak to support sustained flight. Our measurements of *Confuciusornis* specimens suggest that their conclusions need to be further evaluated.

Nudds and Dyke reported their latest analysis on the flight capability of two famous basal birds, *Archaeopteryx* and *Confuciusornis* (*1*). By comparing the rachis (central shaft) diameters of the primary feathers of these two basal birds to those of modern birds, the authors found that the primary feathers of these birds were too weak to support sustained flight and thus concluded that flapping flight might have originated relatively late in avian evolution (*1*).

Nudds and Dyke's innovative analysis offers important new insights into early avian evolution. However, we noticed a substantial discrepancy between their presented data based on specimens with dubious origins and our recently collected data on confuciusornithids and believe that their conclusions need to be further evaluated. Our measurements show that the primary feathers of confuciusornithids have considerably thicker rachises than Nudds and Dyke suggest (*1*).

Measuring the rachis diameter in modern birds appears to be straightforward and easy, but this might not be true for fossil feathers—even for those of confuciusornithids, which are the best documented Mesozoic fossil birds and have some exquisitely preserved feathers (*2*). The Shandong Tianyu Museum of Nature has 536 specimens of confuciusornithids, but only four specimens preserve clear impressions of the rachis of the primary feathers (Fig. 1A). Many specimens exhibit relatively thick parallel lines throughout the wing, but they are preservational artifacts between remiges (flight feathers of a bird's wing) rather than rachises. Several other possibilities leading to smaller measured values include mistaking a covert rachis as a primary feather rachis (Fig. 1B), mistaking the longitudinal ventral furrow of the rachis of primary feathers as the whole rachis, or measuring rachis diameter of primary feathers on the dorsal side rather than ventral side (the diameter is considerably larger on the ventral side) (Fig. 1C).

Fig. 1. (**A**) Well-preserved primary feathers of a *Confuciusornis* specimen (STM13-62, housed at Shandong Tianyu Museum of Nature). (**B**) Right wing of a pigeon in dorsal view. Note rachises of coverts. (**C**) Close-up of a primary feather of a pigeon in ventral (top) and dorsal (bottom) views. Note the considerably wider rachis in ventral view than in dorsal view.

The rachises of primary feathers of confuciusornithids measure 2.1 to 2.3 mm in diameter on four Tianyu specimens, about twice as large as the measurements reported by Nudds and Dyke (*1*). Because the specimen we measured is similar in size to those studied by Nudds and Dyke, it is unlikely that the difference is caused by different body sizes. Nudds and Dyke's study thus underestimates the thickness and strength of the rachises of confuciusornithid primary feathers. Their resulting inference that confuciusornithids were not able gliders and could only parachute thus needs to be further evaluated based on newly collected, more accurate data.

However, even our measurements are considerably smaller than the predicted rachis diameter of primary feathers with similar feather length in similarly sized extant birds. This lends support to Nudds and Dyke's conclusion that basal birds have narrow rachises of primary feathers and thus had poorer flight capability than extant birds (*1*), which is consistent with previous studies (*3*). Furthermore, rachis diameter of the primary feathers is only one of several useful indicators of flight capability, and other features such as the curvature of flight feathers, asymmetry of vanes, and the right angle between the scapula and coracoid in both *Archaeopteryx* and *Confuciusornis* also should be considered. Although Nudds and Dyke's inference about flight capability of basal birds needs more data to be verified, their study outlines one of the future directions on early avian flight. Further investigations on strength of flight feathers of other basal birds, including enantiornithines and basal ornithuromorphans, promise to shed new light on this interesting evolutionary issue.

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References and Notes

1. R. L. Nudds, G. J. Dyke, *Science* **328**, 887 (2010).
2. L. M. Chiappe, S.-A. Ji, Q. Ji, M. A. Norell, *Bull. Am. Museum Nat. Hist.* **242**, 1 (1999).
3. Z. Zhou, J. A. Farlow, in *New Perspectives on the Origin and Early Evolution of Birds*, J. A. Gauthier, L. F. Gall, Eds. (The Peabody Museum of Natural History, Yale University, New Haven, 2001), pp. 237–254.
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