BOOK REVIEWS

The Rise of Birds: 225 Million Years of Evolution. Sankar Chatterjee. 1997. The Johns Hopkins University Press, Baltimore, MD. 312 p. $39.95

I definitely recommend Dr. Sankar Chatterjee's book to those interested in the origin and evolution of birds, although I (and others) disagree with some of Chatterjee's ideas. Much of the book makes detailed comparisons of the anatomical features of birds and their relatives in the archosaurian lineage, making much of it inaccessible without a good anatomy background. The strengths of the book lie in its anatomical comparisons and its attempt to define *Protoavis*' position in avian evolution. The portions dealing with bird flight and the evolution of flight have some interesting hypotheses as well as some weaknesses.

The most important part of Chatterjee's book is the analysis of his most important fossil find, *Protoavis texensis*. Since its discovery in 1983, *Protoavis* has generated controversy, debate, and fascination, so a detailed account of *Protoavis* has been long awaited. Chatterjee's book brings information from several of his publications on *Protoavis* together in one volume. Unfortunately, one key element missing from Chatterjee's book are photographs of the skeletal elements of *Protoavis* so that readers can judge for themselves the accuracy of the reconstructions and drawings done by Chatterjee and his staff. For example, Chatterjee's drawings indicate possible quill knobs on the ulna and metacarpals II and III, which would be strong evidence that *Protoavis* was a bird with flight feathers capable of generating aerodynamic forces. But without photographs of the actual fossils, the readers are not able to make their own judgments on the issue, or other interpretations of skeletal characters.

Chatterjee claims *Protoavis*' skeleton shows signs of being more advanced than *Archaeopteryx*. Chatterjee says *Protoavis* would be capable of powered flight, a trait that is uncertain for *Archaeopteryx*. If *Protoavis* is more advanced than *Archaeopteryx*, then one might expect *Protoavis* to appear more recently in the fossil record than *Archaeopteryx*, yet *Protoavis* predates *Archaeopteryx* by about 75 million years. This may seem unreasonable at first, but it is possible *Archaeopteryx* was a "living fossil" in its day, much like the coelacanth is today. There are difficulties determining if *Protoavis* is more advanced than *Archaeopteryx*. For example, one character shared by both *Protoavis* and modern birds, but not found in *Archaeopteryx*, is the loss of a couple of bony struts in the skull, which makes the upper jaw movable. Chatterjee cites this as one of the characters showing *Protoavis* as more modern than *Archaeopteryx*. It is uncertain if modern birds inherited this feature from *Protoavis*, or if it is convergent evolution. Cladistic analysis depends on being able to differentiate between convergence and common ancestry, which is difficult to determine when specimens are few.

Chatterjee agrees with the prevailing hypothesis that birds are descendants of maniraptoran theropod dinosaurs, probably sharing a common ancestor with the dromaeosaurids. But dromaeosaurids are not known before the latter half of the Cretaceous. For *Protoavis* to have evolved from dromaeosaurids means the dromaeosaurids would have about 125 million years of undiscovered history, dating back to the Triassic, during which they changed very little. Not only would dromaeosaurid evolution be pushed back to the early Triassic, so would most of the divergences of the major lineages in the dinosaur clade, with undiscovered fossil lineages for each. Again, this is technically possible, but is it probable or reasonable? It is a very large assumption in need of much more data. Cladistic analysis is a powerful method of determining evolutionary relationships between organisms, but one weakness is its inability to consider time as part of the equation. The question in the *Protoavis* case is not whether it was possible, but rather is there convincing data that it did happen and that *Protoavis* is a more modern bird than *Archaeopteryx*? It is an interesting hypothesis, but the case is not convincing yet. Much more fossil evidence will be needed to make this case.

The general consensus that birds evolved from small theropod dinosaurs is so widely held that many people may not realize how difficult that consensus has been to reach, or why determining the evolutionary history of birds has been so difficult. Chatterjee gives a general treatment of the competing theories of the origin of birds, but does it in the tenth chapter, not near the beginning of the book. His summary is too brief and does not clearly convey why determining the ancestors of birds has been so difficult. There are several very bird-like archosaur lineages, often showing evolutionary convergences. This is important because if Chatterjee is correct and *Protoavis* is in the bird lineage, then the current bird-dromaeosaurid hypothesis will have to be seriously reevaluated in light of the absence of Triassic or even early Jurrasic dromaeosaurid fossils. A final consensus on the identity and evolutionary position of *Protoavis* has not been reached.

Although Chatterjee agrees with the hypothesis of birds as dinosaur descendants, he has broken ranks with the dinosaur camp on the origin of bird flight. There are two predominant schools of thought on the origin of bird flight. One says birds are dinosaur descendants. Dinosaurs were strictly terrestrial so therefore bird flight evolved from the ground up. The other school says the aerodynamics and biomechanics clearly show bird flight must have evolved from the trees down and since dinosaurs were terrestrial, birds must have evolved from a non-dinosaurian archosaur. Chatterjee assumes that, of the many small dinosaurs, some must have been able to climb trees and one group evolved flight from the trees down. If birds are dinosaur descendants, then I would agree with Chatterjee: Look for the ancestors of birds among small, tree climbing dinosaurs. Chatterjee also presents the hypothesis that climbing by the ancestors of birds and early birds might have been responsible for the migration of the biceps tubercle, leading to the supracoracoideus system birds use to raise their wings. The evolution of the supracora-

coideus system has been difficult to explain. So, this hypothesis deserves serious investigation.

Chatterjee's model for the arboreal evolution of flight does not differ greatly from the model of Bock and others (jumping between branches leads to parachuting, then gliding, then powered flight) with one large exception. Chatterjee proposes two steps in the evolution of bird flight where the ancestors of birds initially jump into water feet first to break their fall, which evolved into diving into the water head first. Although jumping into water can break an animal's fall, doing so is not risk free, with many potential and often hidden hazards in the water. Diving head first into water is a specialized and dangerous activity, used by a limited number of animals in certain circumstances. This hypothesis seems very unlikely and very difficult to test.

The other areas of the book are well done, including a look at the Cretaceous extinction and Dr. Chatterjee's work on the impact theory of the Cretaceous extinction, and overview of other Mesozoic birds, the rise of birds after the Cretaceous extinction, and concluding appropriately with the chapter "Birds and Humans." The last chapter recounts the impact humans have had on birds as well as stating why birds are important to humans. The final line of Dr. Chatterjee's book says of birds and humans, "This is the only home in the entire solar system we can share together." Let's hope we are willing enough to share the planet that we can stop the loss of birds and other species.

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