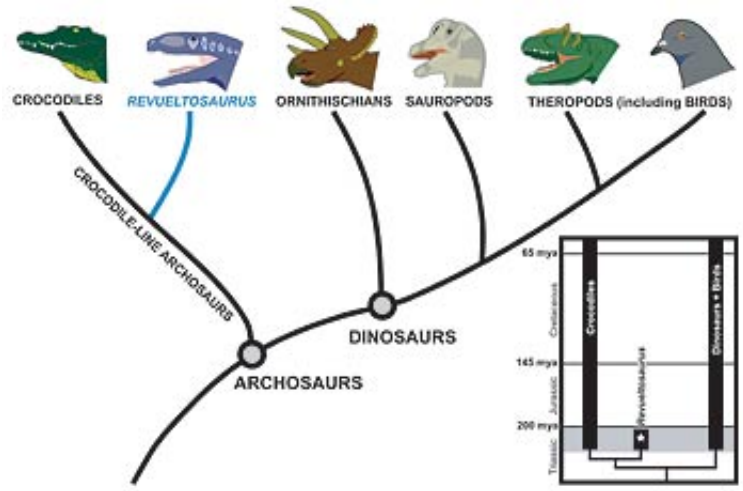
The incredible shrinking dinosaur

May 26 2014, by Sheyna E. Gifford, M.d., M.sc.



An evolutionary tree demonstrating the dinosaur clade and the bird clade that descended from it. Image Credit: Randall Irmis / Andrew Lee / Nick Pyenson

Dinosaurs still roam the Earth - only now, according to researchers at the University of Oxford, they rule the air. At least, according this landmark study, their miniaturized forms do.

"Dinosaurs aren't extinct," said Dr. Robert Benson, vertebrate paleontologist at Oxford University, England, "there are about 10,000 species alive today in the form of birds."

In an ambitious attempt to uncover the root of diversity in animals still alive today, Benson, along with Dr. David Evans of the Royal Ontario Museum and several others, assembled hundreds of evolutionary trees

representing birds/dinosaurs from the Mesozoic era. The Mesozoic era ran roughly from 250 million to 65 million years ago. The "meso-" or middle era of life on Earth saw the rise of dinosaurs and mammals. It later saw the fall of the almost all of the dinosaurs on land. The evolutionary trees showed that one solitary group managed to walk, or rather fly, away from the disaster. Birds were, and are, the one group of dinosaur that never stopped evolving.

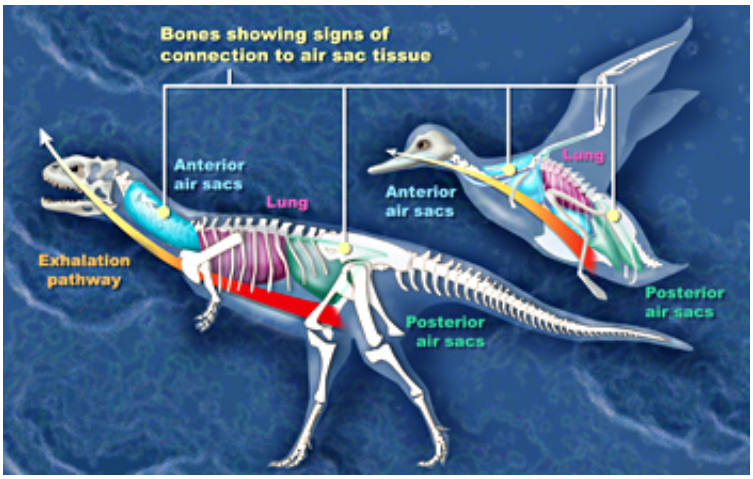
In their recently published paper in *PLOS Biology* , Benson et al describe how at first dinosaurs rapidly diversified into different species, assuming a large variety of shapes and sizes. Each morphology, or permutation of appearance and function, reflected to some environmental niche, or resource area, that the dinosaur adapted to fill.

Once they adapted to fill those niches, most of the dinosaur species "became conservative," or stopped exploring new ecologies through their evolution. Every part of the dinosaur group, that is, except the branch of the evolutionary tree that evolved into what later became birds.

Since the 1970's evolutionary biology has proceeded largely on the assumption that modern birds are descended from non-bird dinosaurs. What's new about this study is that the lineage is traced out by body mass. It showed for the first that when the Mesozoic chapter of Earth's history came to an abrupt end 65 million years ago, large body mass was not conducive to survival, whereas small-very small-was. - See more at: www.astrobio.net/news-brief/th … sthash.5jlaLpbi.dpuf

This is why: the enormous impact that triggered a rapid, prolonged winter decimated the food sources for large animals. According to the fossil record, those birds/dinosaurs that survived and evolved into modern times could have been as small as modern sparrows, which weigh around 15 grams, and are considerably lighter than the smallest non-bird dinosaurs, which weighed about 600 grams. Because of their

small size, these Mesozoic birds had a wide-enough selection food sources to make it to modern times.



This image compares physiology of birds to what may have been present in dinosaurs. Credit: NSF

"If you are a small organism, ecologically you are capable of exploiting microhabitats," said Benson, "We find the greatest ecological diversity [today] in mammals and birds at around 100 grams."

The mass extinction that took place 65 million years ago provided an unprecedented opportunity for tiny dinosaurs that survived to take over wherever the larger dinosaurs couldn't find food: which was nearly everywhere. With most other land animals extinct, the niches of the world now belonged to the birds.

Having achieved basic survival by shrinking, and having thrived by eating what others could not, the next step for small dinosaurs/birds was staking a permanent claim to each newly exploited niche. The key success in the recently remodeled world was rapid transformation or

adaptive radiation.

"Adaptive radiation is the idea that evolution sometimes allows organisms to do something new for the first time," said Benson.

In this model of adaptive radiation, the clade of dinosaurs radiated a clade of birds. The bird clade then rapidly diversified, radiating branches for each of the many species that filled the Earth. After every land dinosaur weighting over a kilogram died the birds took over their niches, adaptively radiating as they went. In this way, adaptive radiation allows species to take advantage of ecologic diversity it is exists in the world, and at the same time become ecologically diverse themselves.

Furthermore, according to this hypothesis, the dinosaurs that became birds didn't just go small and diverse: they continued to do so for the next 170 million years.

Caption: An Oxford University-led team studied how dinosaurs evolved into a huge range of shapes and sizes over 170 million years. Shrinking their bodies may have helped the group that became birds to continue exploiting new ecological niches throughout their evolution. Credit: Julius Csotonyi

"Birds owe their success not just to recent adaptive radiation, they owe their evolutionary success to a long-term history of finding new niches over hundreds of millions of years," said Benson, "The rates of [bird] evolution never slowed down. They continued to find and exploit new niches throughout their ecologic history."

Fast-forward to the present: birds are the most successful land vertebrate by a long shot. Today there are 300 times more species of birds than species of crocodiles, even though both are descended from a dinosaur-like ancestor that lived 250 million years ago. The birds branched out because the land changed, whereas crocodiles lurked in freshwater, and seem to have lacked the evolutionary potential to change further, with no new niches to expand into. As a result the birds, said Benson, "are doing all kinds of things in the environment, whereas crocodiles are doing basically one thing."

Benson and Evans' model of continuous niche-filling on the part of the birds explains much of what we see in the world today including the dinosaur-descendant double-standard that exists between crocodiles and birds, how birds became the most successful land vertebrates, and why most birds are small and why ostriches and emus are the exception rather than the rule. Their hypothesis draws a line, or rather a long series of lines, that outline the relationship between species extinct since the Mesozoic and the diversity of those still alive today.

According to their hypothesis, the mechanism behind dinosaurs

surviving to the present as 10,000 bird species was miniaturization followed by adaptive radiation: leaving no useful ecological niche unfilled. If there was a place to move into with something to eat, birds moved there and adapted. Then they kept moving, kept adapting and kept surviving. Here, not just evolvability, but maintenance of evolvability, is the key.

In other words: re-sizing matters.

More information: Benson RBJ, Campione NE, Carrano MT, Mannion PD, Sullivan C, et al. (2014) Rates of Dinosaur Body Mass Evolution Indicate 170 Million Years of Sustained Ecological Innovation on the Avian Stem Lineage. *PLoS Biol* 12(5): e1001853. DOI: 10.1371/journal.pbio.1001853

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