

I'm Alexander Suh, my paper evaluates the evolutionary signature of modern birds and discovered extreme degrees of complex conflict at onset of the “big bang” of modern birds, when speciation of birds began rapidly after dinosaur extinction – AMA!

PLOScienceWednesday<sup>1</sup> and r/Science AMAs<sup>1</sup>

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### **Abstract**

Hi Reddit, My name is Alexander Suh and I am a postdoctoral researcher at Uppsala University in Sweden. My research focuses on the evolution of birds and their genomic parasites, such as transposons and viruses. We recently published a study in PLOS Biology titled “The dynamics of incomplete lineage sorting across the ancient adaptive radiation of neoavian birds”. There we analyzed the evolutionary signature of what some call the ‘big bang’ of modern birds, a rapid succession of speciation events following the extinction of dinosaurs. We used ancient retrotransposon insertions from 48 bird genomes to reconstruct evolutionary relationships, showing that most of the bird Tree of Life can be reliably resolved by our study and previous studies. However, we were surprised to find that the very onset of the ‘big bang’ of modern birds harbors extreme degrees of conflict. In fact, the conflicts are so complex that they look more like a network than a tree. Our explanation for this complexity is that bird speciation in the direct aftermath of dinosaur extinction was extremely rapid, potentially too rapid to be resolvable as a single tree. I will be answering your questions at 1 pm EST (10am PST, 7 pm CET). Ask Me About Birds, Transposons, Anything! Don't forget to follow me on Twitter @alexander\_suh and visit my website.

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# PLOS Science Wednesday: I'm Alexander Suh, my paper in PLOS Biology evaluates the evolutionary signature of modern birds and discovered extreme degrees of complex conflict at onset of the “big bang” of

PLOSSCIENCEWEDNESDAY [R/SCIENCE](#)

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My name is Alexander Suh and I am a postdoctoral researcher at [Uppsala University](#) in Sweden. My research focuses on the evolution of birds and their genomic parasites, such as transposons and viruses.

We recently published a study in [PLOS Biology](#) titled “[The dynamics of incomplete lineage sorting across the ancient adaptive radiation of neoavian birds](#)”. There we analyzed the evolutionary signature of what some call the ‘big bang’ of modern birds, a rapid succession of speciation events following the extinction of dinosaurs.

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As someone who's fascinated by evolutionary theory, I'm curious about the time window in which this rapid speciation occurred. Did theropods evolve into birds *as a result* of the extinction event, or had the ones that survived already evolved into birds which somehow enabled them to survive the resulting climate change?

[sensitivePornGuy](#)

The exact dates of some of these early speciation events are still debated, but it is now widely accepted (both from fossils and DNA analyses) that by the time of **the** extinction event (K-Pg boundary, ~66 mya), modern birds had already existed for quite a while.

In fact, at least the following four lineages of modern birds (i.e., ancestors of extant birds) did exist prior to the K-Pg boundary and survived it: - ancestor of the ostrich - ancestor of tinamous, emus, kiwis etc. - ancestor of chicken, ducks, etc. - ancestor of all remaining birds, the **Neoaves**

The rapid speciation that we studied only applies to one of these four lineages, the Neoaves. There are several DNA studies now that suggest that this did in fact coincide with the K-Pg boundary (e.g., [Jarvis et al. 2014](#), [Prum et al. 2015](#), [Claramunt, S. & Cracraft 2015](#)).

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Hi Dr Suh. I'm really interested in the early radiation of birds, in particular the impact of transposable elements. Why do you think the avian genome is so low in repetitive elements? In your 2015 paper you describe a hairpin structure and an octomer as making CR1s immobile and hence not in large numbers, but in comparison to mammals other transposable elements are also much lower in number.

[the\\_khajiit\\_of\\_lies](#)

The low density of repetitive elements (especially transposons) coincides with small genome sizes of extant birds (~1/3 of a human genome; ~1/2 of their closest alive relatives, the crocodilians).

It is still a bit of a mystery as to how exactly the ancestor of birds reduced their genome size by 50%, but here is my transposon perspective: Birds appear to be quite good at repressing transposons, i.e., stopping them from increasing their genome size. Most of the "typical" transposons of land vertebrate genomes were lost in the bird ancestors, with CR1 (*chicken repeat 1*) being one of the few surviving transposon lineages. Once the genomes were small, they maintained their size through high rates of meiotic recombination. This is especially possible because most of the chromosomes of a typical bird genome are tiny, so-called microchromosomes. Imagine that a transposon always tries to make lots of copies of itself. The best way for selection to efficiently remove these new mutations from the bird population is frequent meiotic recombination. By doing so, their genomes don't increase in size but stay "slim".

Hello Dr. Suh,

I am a layperson and not scientifically trained, but am a passionate birder. I have heard that the Hoatzin *Opisthocomus hoazin* is from the oldest line of birds that are currently alive, having split off from the rest of the birds 64 million years ago. Its appearance looks positively prehistoric, as if they have not changed at all in those 64 million years. My question is realistically how much has a bird with such an old lineage changed in its history? And why did it split off so early? Also for more of a "fluff" question, what is your favourite species of bird?

Furthermore I have some doubts on ring species or species complexes such as *Larus* gulls, the various Redpolls and Greenish Warblers *Phylloscopus trochiloides*, among others. My question is how do scientists decide which of these get species status? How come that some species have huge variation (for example Common Buzzard *Buteo buteo*) and are considered to be the same species whereas others such as the Redpolls are hardly separable in the field yet are considered to be different species. How does this work?

[YoSoyUnPayaso](#)

I agree that the hoatzin is a weird bird and looks somewhat "prehistoric" (their chicks have claws on their wings!). I guess this one and hummingbirds are my favorite birds.

The hoatzin ancestor split off other neoavian birds ~64 mya, however, it is not the deepest lineage of living birds! The deepest split is between the ancestor of ratites + tinamous and the rest of birds (neognaths), then there's a split between chickens + ducks and the rest of the rest of birds (Neoaves). From that perspective, the hoatzin is not *that* "old". I am not familiar with the fossils of this lineage, but at least in terms of molecular evolution (single basepair mutations and transposons), the hoatzin has been continuously evolving like any "normal" bird.

The ring species and species complexes you mention will likely undergo quite some taxonomic changes in the next year. The more DNA is looked at, the more complex the picture gets. My personal (non-scientific) guess is that many of these complexes may somewhat resemble the rapid radiation of Neoaves, just on a much more recent timescale.

Do you think all modern birds evolved from a common saurian ancestors, or do you believe multiple species of saurians developed the same traits and eventually evolved into the birds we know today? Or is this little more than semantics?

[Akesgeroth](#)

**What is a bird?** A theropod dinosaur doing powered flight.

Modern birds (Neornithes, *including all extant birds*) evolved from a common ancestor that is nested within birds (Avialae/Aves), which in turn are nested within theropod dinosaurs (Theropoda). The fossil record is quite amazing for this gradual evolution of typical bird traits. Very interesting reads on this topic are by [Darren Naish](#) and [Lee et al. 2014](#).

It's a pity that all the archaic birds and remaining dinosaurs became extinct such a while ago (~66 million years ago and only descendants of the modern bird ancestor survived), otherwise we could draw some fascinating insights from their DNA.

Has your work strengthened the link between dinosaurs and birds? Is there thought to be a single dinosaur ancestor or multiple?

[Cynthereon](#)

Jurassic Park was *a bit* optimistic here. Unfortunately, non-avian dinosaurs became extinct such a while ago (~66 million years ago) that we cannot extract DNA from their fossils. We thus cannot test the bird-dinosaur link in DNA studies, but there are plenty of fossils to show that. What we can show using DNA is that the closest *living* relatives of birds are crocodylians, so birds are not only dinosaurs, but reptiles!

Hello Alexander, Thank you for doing this AMA. I am only a hobby chicken breeder, but there is a debate in the domestic fowl breeding world about the origins of certain chicken breeds which I would be honored to hear your thoughts on. The mainstream belief is that all domestic chickens were bred from Gallus gallus, the jungle fowl, as what is likely the first domesticated livestock animal, yet there is some reason for belief that people in South America developed a similar chicken-like domesticated fowl. Modern Collonca chickens are rumpless, and very distinct, but can interbreed with other domestic chickens. Would you say it was possible that an early ancestor of Gallus co-evolved in South America and then developed by selective breeding, or do you believe that it is more likely South American chickens were brought into the Americas by early people, and all of them are derived from Jungle Fowl?

Thank you!

[MainersLady](#)

To my knowledge, none of the *Gallus* species originally occur in the New World, all chickens were brought there by humans. This is not my field of expertise, but I suspect that all chicken breeds are derived from jungle fowl. What is interesting though is that some breeds might have gotten to the New World in pre-Columbian times, brought there by Polynesians ([Lawler 2014](#)). Fossil data supports this, but there is a bit of an ongoing debate between DNA-based studies (e.g., [Storey & Matisoo-Smith](#)).

Did the rapid speciation of birds also cause a correlating change in their genomic parasites? Is there a really neat or interesting change that can be specifically attributed to the parasites? Thank you!

[lady\\_epperly](#)

[In an earlier study](#), we found that the rapid speciation of neoavian birds was accompanied by an unusual amount of different transposons that made quite a bunch of copies during that time. That's what transposons do - make copies of themselves as a parasite within a genome - but they seemed to have done that particularly well during the rapid speciation. The problem is: What was first; chicken or egg, rapid speciation or transposons?

So which bird(s) did you find to be the most ancient of the ones you studied?

[mrbucket777](#)

We studied 48 birds, all of which are extant species. From that perspective, all are equally ancient/young. However, some birds (songbirds, woodpeckers, parrots) evolve faster than others, i.e., they accumulate more mutations over time. On the other hand, secondarily flightless birds (penguins, ostrich) are evolving much slower. From that perspective, their genomes might be considered more similar to the genome of the bird ancestor.

How quickly did these changes happen?

Also how hard is interbreeding between birds? Is there a parallel to something like dogs or are they too different?

[VicMG](#)

As far as we can tell from the genomic signatures of rapid speciation (a phenomenon called "incomplete lineage sorting", ILS) in our study, the very beginning of this rapid speciation might have been super-rapid.

How rapid? It appears that the first ~9 lineages of neoavian birds emerged nearly simultaneously and speciation then slowed down gradually. It is possible that interbreeding (gene flow) did happen between these very young species, further complicating the picture.

It is tricky to compare this to dogs because they are artificial populations of the same species and without humans they might all look like wolves (because they are... wolves).

Gene flow between young species is hard to tell apart from ILS. Furthermore, it is a bit different from the gene flow (hybridization) we can see between some distinct (long-diverged) species of extant birds. Extreme examples here are ducks and birds-of-paradise. For the Neoaves rapid speciation, we tested cases where we assumed that such hybridization might have happened, but found no evidence for it.

What could be the sources of such rapid speciation? Birds occupied a completely new branch of niches, could this be the cause of speciation? Niche availability?

[piperman](#)

Niche availability seems plausible, given that at the K-Pg boundary, archaic birds and non-avian dinosaurs became extinct. It remains a bit of a mystery why the ancestor of Neoaves was so successful though. Why not the ancestor of chickens + ducks, or the ancestor of tinamous + emu, or the ancestor of the ostrich? These lineages existed before the K-Pg boundary and survived the mass extinction.

How much intertwined is the evolution of early birds and last dinosaurs? Let's take the closest common ancestor of all birds. Did it also have non-birds but dinosaur-like descendant? How much dinosaur-like?

[\\_ch3m](#)

A bird is a dinosaur capable of powered flight. The common ancestor of all birds (Avialae/Aves) looked a bit more like a "typical" theropod dinosaur and the common ancestor of all modern birds (Neornithes) looked a bit more like extant birds. [Darren Naish](#) has written great articles about what fossils tell us about this gradual transition from a "typical" theropod dinosaur to birds, these special theropod dinosaurs capable of powered flight.

We're there any notably different birds that failed to make it to the current age?

[Deeliciousness](#)

There were lots of them, and thanks to them there is a detailed record for the gradual evolution of powered flight in birds!