# News & views

Palaeontology

## The lost long tail of early bird evolution

**Stephen L. Brusatte**

In the nineteenth century, the discovery of the fossil *Archaeopteryx* revealed how birds evolved from dinosaurs. A bird fossil of similar age to *Archaeopteryx* shows flight-aiding innovations such as the loss of a long tail. **See p.441**

In 1861, as quarry workers in the Bavarian countryside split limestone into sheets for use in lithographic printing, they happened on a fossil skeleton. It had feathers and wings, so it was clearly a bird – but it sported a long tail and sharp claws, which seemed reptilian.

Named *Archaeopteryx*, this fossil sparked a radical idea – that today's birds evolved from primeval dinosaurs. The hybrid bird was heralded by Charles Darwin as support for his theory of evolution by natural selection, published just two years earlier. Furthermore, at 150 million years old, *Archaeopteryx* proved that birds were already soaring by the end of the Jurassic period. Palaeontologists of the time surely expected more Jurassic birds to emerge from the fossil record, but alas, the rocks have been mostly silent – until now. On page 441, Chen *et al.*[1] describe only the second known Jurassic species to be classified unequivocally as a bird.

Welcome *Baminornis zhenghensis*, a lightweight creature that could easily fit in the palm of your hand. Its name refers to where it was found – in Zhenghe County of Fujian province, in southeastern China. Here, the mudstones are 148 million to 150 million years old and belong to what is called the Nanyuan Formation. They are yielding some of the most exciting newly discovered fossils in the world, termed the Zhenghe Fauna. Only limited fieldwork has been conducted thus far, but it has already uncovered more than 100 fossils, many of which are beautifully preserved. Most are aquatic or semi-aquatic animals such as fishes and turtles, but just over a year ago, a small, delicate skeleton was discovered. This new species of dinosaur, *Fujianvenator prodigiosus*, is thought to be one of the closest relatives of birds[2]. Now, *Baminornis* shows that members of the group Avialae, or true birds – essentially the ones that could power themselves through the air by flapping[3] – lived alongside their dinosaur cousins in China during the Jurassic period.

*Baminornis* is a landmark discovery, and ranks among the most important bird fossils unearthed since the discovery of *Archaeopteryx* in the early 1860s (Fig. 1). In the years after that first find, *Archaeopteryx* skeletons surfaced in other limestone quarries nearby. Fourteen skeletons are now known, and there is debate about whether they belong to one or several species[4]. Regardless of this, they were all primitive birds with fairly small wings, toothy jaws and feet that could grab things (raptorial feet). The creatures could probably fly – but not very well[5]. To be glib, as the palaeontologist John Ostrom once quipped, *Archaeopteryx* basically has the skeleton of a generalized small meat-eating dinosaur, just with wings[6].

A smattering of other feathery Jurassic fossils, including those known as anchiornithids and scansoriopterygids, might be birds, but their classification is contentious, because many genealogical analyses instead identify them as non-bird 'raptor' dinosaurs in the *Velociraptor* zone of the evolutionary family tree[7]. Nevertheless, they too were primitive aerialists that lacked many of the key flight-related adaptations of modern birds, such as shortened tails and modified shoulder girdles for powerful flapping.

*Baminornis* is different. It more closely resembles modern birds than *Archaeopteryx* does, in two particular ways. First, it lacks the long tail seen in raptor dinosaurs and in *Archaeopteryx*; instead, some of its vertebrae are fused into a short, stubby nubbin called a pygostyle. Those of us who roast chickens for

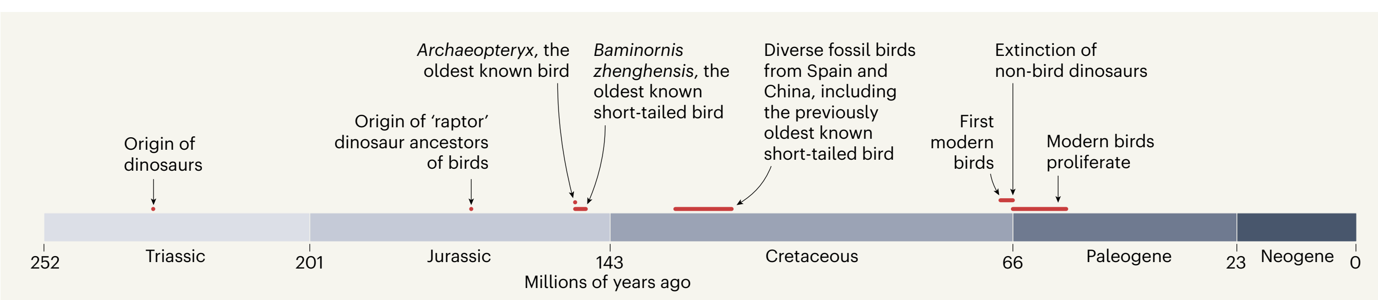


**Figure 1 | A timeline of key fossil discoveries that have helped scientists to understand how birds evolved.** Dinosaurs diversified after they first arose about 231 million years ago during the Triassic period, and by around 170 million years ago, during the Jurassic period, dinosaurs with feet capable of grasping and slashing things ('raptor' dinosaurs) had evolved. These dinosaurs were the ancestors of birds. Until now, fossils of only one unequivocal bird, *Archaeopteryx*, had been identified from the Jurassic period. This species from 150 million years ago had feathers, but it also had a long tail, characteristic of dinosaurs. Chen *et al.*[1] report the identification of fossils of another Jurassic bird, *Baminornis zhenghensis*, from 148 million to 150 million years ago. This bird had some features characteristic of modern birds, such as a short tail. The oldest short-tailed bird previously known is 120 million to 131 million years old and from the Cretaceous period. Fully modern-style birds began to arise 66 million to 68 million years ago, and these came to prominence after an asteroid strike 66 million years ago led to the extinction of non-bird dinosaurs.

dinner might have come across the pygostyle in the context of the 'parson's nose', a fleshy and fatty bulge at the back of the bird that consists of the pygostyle and its surrounding tissue. The pygostyle has several aerodynamic functions. It anchors flight feathers, reduces drag (relative to the levels observed for birds with a longer tail) and helps to shift the centre of mass forwards towards the wings, which aids biomechanics.

Second, the shoulder girdle of *Baminornis* is refashioned so that the scapula and coracoid bones are separate and the coracoid is strut-shaped – adaptations that are associated with the bespoke musculature and arm motions of flapping flight. These anatomical features indicate that *Baminornis* was probably better at flying than *Archaeopteryx* was, and that it might even have been a better flyer than some other primitive birds from several million years later in the Cretaceous period.

With that said, *Baminornis* was no swallow or albatross. Today's birds have huge, wing-beating muscles – the succulent meat of a chicken breast – that fasten onto a gigantic bony breastbone. *Baminornis,* however, has no such bone, so it's unclear how big its flight muscles were and where they attached. Furthermore, its hand looks similar to that of a raptor dinosaur: individual fingers that could grab and slash, each with many bones, rather than the solid fused structure that secures the primary wing feathers of birds today. And, because its feathers have not been preserved, we don't know how the wings of *Baminornis* were constructed, or even how big they were.

It all makes me wonder how well *Baminornis* could fly, and whether it flew in a manner similar to birds we know or with its own style. Even the presence of a pygostyle doesn't necessarily prove that *Baminornis* had strong flight capabilities, because many dinosaurs closely related to birds – even some ground-living species – independently evolved shortened tails for various reasons[8]. Ultimately, to understand how *Baminornis* flew, rigorous biomechanical modelling and hypothesis testing will be needed, and this will be a fruitful next step in research on this remarkable fossil.

No matter how acrobatic *Baminornis* was in the air, this fossil provides striking evidence that birds were more diverse early in their history than was previously thought. There was probably a bevy of birds – long-tailed ones similar to *Archaeopteryx*, short-tailed ones such as *Baminornis*, maybe even muscular flappers, as suggested by a single provocative wishbone (the fused collar bones that act as a spring to store energy during flight) discovered in the same rocks as *Baminornis* – flying over the heads of *Brontosaurus*, *Stegosaurus* and other iconic Jurassic dinosaurs. More fossils must be out there, in those rare places that can preserve delicate skeletons, so let's keep looking.

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Particle physics

# Neutrino barrels through deep waters near Sicily

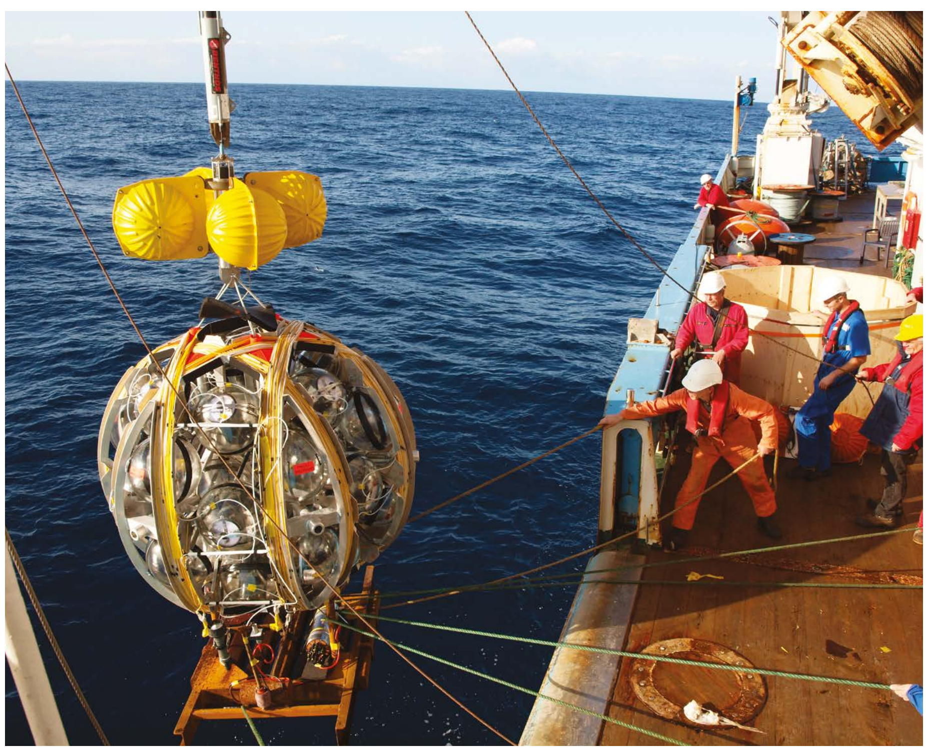
**Erik K. Blaufuss**

The observation of a neutrino in an enormous underwater detector has confounded physicists. It is much more energetic than any particle observed previously, suggesting that it came from a distant astrophysical source. **See p.376**

For the past decade, a new kind of telescope has been observing the skies[1]. Instead of light, these telescopes detect neutrinos – tiny subatomic particles that are usually associated with radioactive decay here on Earth, but can also come from distant sources in the Universe. Observations of 'cosmic' neutrinos provide key insights into the physical processes that power these astrophysical objects.

On page 376, Aiello *et al.*[2] report evidence of the highest-energy cosmic neutrino detected so far, which zipped through their detector deep in the Mediterranean Sea. The energy of this nearly massless particle is around 10,000 times larger than that generated in the largest particle accelerator made by humans, and its origin remains unclear.

Neutrinos are notoriously difficult to detect,



KM3NET COLLABORATION

**Figure 1 | Constructing an underwater neutrino detector.** The neutrino telescope KM3NeT is still under construction in the depths of the Mediterranean Sea. This launch vehicle contains several light sensors strung together with cable that will be anchored to the sea floor.