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NOTES&THEORIES

DISPATCHES FROM THE SCIENCE DESK



How I got to know thunder thighs, the dinosaur with a fearsome kick

Mike Taylor explains how his team reconstructed the probable body shape and lifestyle of a dinosaur from scattered bones, and the importance of distinguishing data from informed guesswork



Bones from the Brontomerus 'thunder thighs' dinosaur reconstructed by Mike Taylor and his team at University College London. Photograph: Mike Taylor/UCL

"There is something fascinating about science," Mark Twain wrote. "One gets such wholesale returns of conjecture out of such a trifling investment of fact."

The question "how do they know that?" is always quick to arise in response to any scientific discovery, as the comments on any Guardian science article confirm. Quite right too. It's the key question that scientists should always ask, and always be ready to answer about their own work.

In my own science, palaeontology, that question looms large. Small animals can be quickly buried and fossilised, but larger corpses are more likely to be scavenged and broken up, or decompose. So the bigger the animals we study, the less fossils we generally get to work with. I work on the long-necked sauropods, the largest of all dinosaurs, which grew to 70 tonnes or more. The great majority of sauropod species are known from only a single specimen each, and most of these are horribly incomplete.

My own baby, Xenoposeidon, named in 2007, is based on part of a single vertebra, and there are plenty of others known only from similarly scanty remains. How can we know anything about an extinct animal when we work from so little evidence?

The discovery of our newest sauropod, *Brontomerus mcintoshi*, was announced last month. Happily it is based on more bones than Xenoposeidon, but still only about 10% of a whole skeleton. You might legitimately ask, how can we reconstruct an animal bigger than an elephant, and even speculate about its behaviour, when all we have is a set of bones that fits comfortably on a one-metre-square table?

First of all, the amount of a skeleton that you have can be misleading. The *Brontomerus* bones include a shoulder blade and a hip bone – only one of each, both from the left side – but because skeletons are symmetrical these bones convey as much information as if we had both the left and right versions. Similarly, we have one vertebra from the middle of the tail. The vertebrae do change along the tail, but the change is slow, so any given vertebra will be very similar to the few that were before and after it. We have only one complete rib, but that tells us something about the other ribs.

In theory, a skeleton that is less than 50% complete could tell you all there is to know about the animal.

The few preserved *Brontomerus* bones also give us an idea about the shape and size of the animal. By comparing these bones with those known from more complete sauropod skeletons, we can get some sense of where it fits into the family tree. And by comparing the size of our dinosaur bones with the analogous bones in related animals, we can get a broad sense of how big our beast was.

It can be a bit unnerving to see how precisely these imprecise estimates get reported, though. For example, our four attempts at estimates for the total mass of the animal yielded 4,666, 6,041, 6,300 and 9,563kg – an uncertainty factor of more than 2 – but this necessarily got condensed down to "around 6 tonnes" for the press release. Still, that's at least enough to know that it was roughly elephant-sized rather than cow-sized or whale-sized.

Many parts of the *Brontomerus* skeleton are completely missing – we have nothing at all

from the skull, neck or limbs. Yet we named the dinosaur after its hind limbs – Brontomerus means "thunder thighs". How can we do that when we don't have any of the limb bones?

Because bones don't work in isolation. Animals' bodies are complex objects, and units of the skeleton work together. Hind limb function depends on the pelvis, the legs themselves and the tail, but if we have the pelvis (or in our case part of the pelvis), we can draw some conclusions about how the whole complex worked.

In this case, we have an ilium, the uppermost of the three bones that make up the pelvis and the one that most of the leg muscles attach to. (We can be confident that was true in dinosaurs because dissections of birds and crocodilians, their closest living relatives, show that these muscles work in broadly similar ways in both groups, forming an evolutionary bracket around dinosaurs.)

The ilium of Brontomerus tells us a lot. The lower margin of a dinosaur ilium forms part of the hip socket, and the upper part consists of a flattish plate of bone where muscles were anchored. In Brontomerus, the plate at the front of the ilium is hugely enlarged compared with other sauropods, so we deduce that the muscles that attached there were correspondingly enlarged. (These are called protractor muscles, and pull the leg forward.) The surprising aspect is that it's only the front part of the plate that's enlarged, while the part behind has shrunk down to almost nothing. Does this mean that Brontomerus had weak retractor muscles?

Not necessarily. Once again, comparisons with living animals come to the rescue. In crocs, the main retractor muscles attach not to the ilium but to the tail base, and details of the bones indicate that the same was true in dinosaurs. So it's possible that Brontomerus had extra-strong retractors as well as protractors. Unfortunately we don't know, because we have no vertebrae from the base of the tail.

So what were the large protractor muscles doing? If the retractors were not also enlarged, then the leg was optimised for being moved quickly forwards: in a word, kicking. In the absence of evidence for strong retractors, and especially in the light of a reduced attachment area for these muscles at the back of the ilium, kicking seems like the simplest and most likely explanation, so that's the angle that we played up in the media.

*Brontomerus*

mcintoshii in action. Image: Francisco Gascó

But the paper is more circumspect and also mentions several other possibilities. Perhaps *Brontomerus* was generally muscular and athletic? It's exciting to imagine it in a full-throttle, rhino-like gallop. Alternatively, the powerful muscles may have driven unusually long legs: *Brontomerus* might have appeared as a dinosaurian giraffe. Finally, the enlarged part of the ilium also anchors abductor muscles in living animals – muscles that draw the leg away from the midline, and which are important in bipedal standing and even walking. Could it possibly be that *Brontomerus* could rear up, or even walk on two legs?

If this discussion leaves you with the impression that we have more questions than answers, you're right. That 10% of the skeleton does tell us a lot – not least that it represents a new dinosaur, not a specimen of an old one. But it also leaves huge gaps in our understanding. The possibility that *Brontomerus* was athletic can't be evaluated without the tail base; the notion of long hind limbs requires the bones of the leg; and the idea of bipedality will remain speculation in the absence of fore limb fossils.

Physicists, chemists, and indeed zoologists who work on living animals, may be appalled at the level of speculation that necessarily goes into large-animal palaeontology. The best we can do is to maintain, as Douglas Adams put it, "rigidly defined areas of doubt and uncertainty".

In writing up fossils like *Brontomerus*, we have to be absolutely clear about the distinctions between data, reasonable inference, informed speculation, and sheer guesswork. Sometimes those distinctions are lost when we have to summarise the work in a two-minute radio interview, though even then we try to hedge our statements with phrases such as "it seems likely that ..." and "it make sense to think that ..." But the important thing is to be clear about data, inference and guesswork in communication with our fellow scientists.

One of the great things that has come out of the publication of *Brontomerus* is that plans are now afoot to go back to the quarry and look for more fossils. Nothing would be more exciting than to find more and better material of this dinosaur – maybe even the elusive complete skeleton. If that happens, we will find out whether *Brontomerus* really was a kicker or a galloper, or maybe a long-legged beauty.

We may find that we were wrong in some or even all of our informed guesses. Maybe even that the bones we thought belonged to *Brontomerus* are in fact from two different dinosaurs.

But that's OK: it's how science progresses. We do what we can with what we have, and hope that those who follow can do better with more.

Dr Mike Taylor is at the Department of Earth Sciences, University College London

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Comments

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Myzlt

9 March 2011 2:43PM

Lovely article highlighting scientific method supported by an on-going narrative.

I hope you get to go back for a second dig, and find some more of your new pet* :)

*Disclaimer: Sauropods are unlikely to make good pets, and this post in no way encourages a Jurassic Park-type project with a view to every boy and girl having a *Diplodocus* in their back garden.

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SharmElShaaaarrkkk

9 March 2011 2:54PM

How I got to know thunder thighs

I bought her a drink back when she was light drizzle thighs. Then

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CrewsControl

10 March 2011 1:44PM

Brontomerus' big protractor
 The boffins tell us is a factor
 In deciding he was a kicker
 But I humbly beg to differ
 I fear they got this one wrong
 The nerve involved is far too long
 Signal conduction involves delay
 And that, no doubt comes into play
 When this dumb dino's pedal thrust
 Hits not predator, only dust.

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MikeTaylor

10 March 2011 3:17PM

Hi, CrewsControl, and thanks for your beautifully phrased comment!

But in response, I refer you to a comment left by my *Brontomerus* co-author Matt Wedel (who knows a lot more soft-tissue anatomy than I do), over on our long-running sauropod blog: <http://svpow.wordpress.com/2011/03/03/genesis-of-an-instant-palaeo-art-classic/#comment-10145>

In short, the brain-to-hip distance is 6m, nerve signals travel in the region of 60-120 m/s, so the reaction time would have been something like 1/20-1/10, with selective pressure of course pushing down towards the lower end of that range.

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CrewsControl

10 March 2011 6:08PM

One hundred metres per second is quick
 Which explains the speed of Rooney's kick
 But sauropods are not warm-blooded
 (Is this a feature that you've studied?)
 And if body temperature is lower
 Nerve conduction will be much slower

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**MikeTaylor**

10 March 2011 7:01PM

CrewsControl, I wish I could do you justice by replying in rhyme, but I think that's a unique gift you have there! Yes, dinosaurs were warm-blooded: lots of independent lines of evidence indicate that their basal metabolic rates were much higher than those of extant crocs, lizards, snakes and turtles. While we can't place them precisely on a metabolic-rate scale (and indeed different dinosaurs no doubt had different metabolism), it's not unreasonable to think that, like their closest living relatives, the birds, they had metabolic rates *higher* than those of mammals such as ourselves. Certainly histological evidence indicates that juvenile sauropods grew as fast as, or faster than, elephants -- and that without the huge benefit of drinking nutritious milk.

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