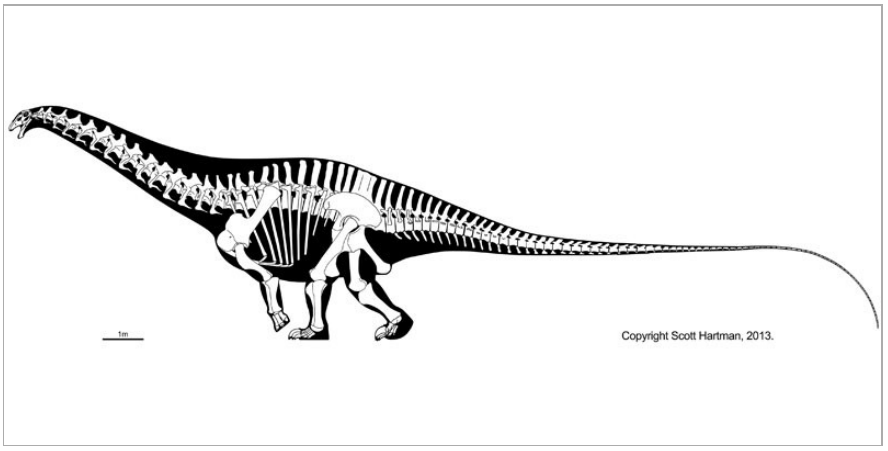
May 30, 2013, 4 p.m.

A bipedal Diplodocus? It's not as crazy as it sounds...



Mike Taylor *Computer programmer and palaeontologist: University of Bristol*

Dr Mike Taylor is a computer programmer in his day-job, and a Research Associate at the University of Bristol. He has the luxury of working almost exclusively on sauropods, the most impressive and inspiring of all dinosaurs.

ON APRIL FOOL'S DAY, dinosaur artist Scott Hartman posted an article on his blog called 'Massive changes incoming to diplodocid sauropod stance'. It showed a skeletal reconstruction of an ***Apatosaurus*** running on its hind limbs. It looks funny because it's so different from how we think of sauropods (the long-necked dinosaurs) - but could it have happened?

Like a lot of left-field ideas, it has actually been around for a while, and has been mentioned in the occasional magazine. But it hasn't often appeared in the technical literature and I've never seen a life restoration of a sauropod running or walking on two legs. In the spirit of inquiry, Scott has adjusted his April Fool's day illustration above to represent a more plausible bipedal ***Apatosaurus***.

One sauropod that has been proposed as a biped is ***Cathetosaurus***, described by Jim Jensen in 1988. It's since been recognised as a species of ***Camarasaurus***, but the specimen that the name was based on differs from all other ***Camarasaurus*** individuals in two important ways.

First, it was very old at the time of death. Determining the age of dinosaurs from fossils is not an exact science, although studying the microscopic structure of the bones can be very informative. This allows us to see growth rings, which increase with age.

Even when absolute age can't be found, relative ages can usually be established by looking at which bones are fused together. Just as the bones of a baby's skull progressively fuse during its first 18 months, so the bones of older sauropods become more fused. The top and bottom parts of each vertebra become united, the ribs of the neck fuse to their vertebrae, the vertebrae of the hips coalesce into a single unit, the shoulder bones fuse together, and so on.

In the oldest specimens, even tendons start to ossify [turn to bone] – and this is what happened with '***Cathetosaurus***', whose consecutive vertebrae are braced by fossilised diagonal struts.

The second unusual feature of this specimen is the fusion of its hip bone to the vertebral column. In all other sauropods, the spine is more or less parallel to the long axis of the hip bone; but in '***Cathetosaurus***' it is tilted upwards by about 15 degrees.

Jensen interpreted the upward tilt as "evidence for persistent, voluntary bipedalism", and thought the diagonal bony struts provided bracing for the bipedal posture. A later re-evaluation of his specimen showed that the struts are an age-related feature: it's likely that all sauropods had these struts as

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ligament, but they turned to bone only in very old individuals.

That still leaves the mystery of the inclined pelvis. No-one has yet suggested another interpretation of this feature, and it's very far-fetched to imagine that it's age-related.

The real oddity here is that if you were to choose a sauropod that would be most likely to walk on its hind legs, or even stand up on them, it wouldn't be a camarasaur because they are rather front-heavy.

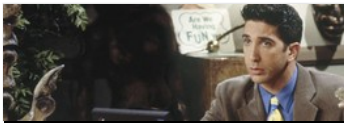
In order to rear up, you need to get your centre of gravity back over the hind feet. In the 1980s McNeill Alexander showed that front-heavy sauropods such as *Brachiosaurus* would find this very difficult, but that it would have been relatively easy for back-heavy sauropods like *Diplodocus*.

In the last few years, Heinrich Mallison's detailed computer models have confirmed this, and we now have very good reason to think that *Diplodocus* – with its light neck, short torso and long, heavy tail – was a capable rearer: much more so than '*Cathetosaurus*'.

Standing on two feet is one thing. Walking bipedally is another altogether. Surprisingly, nearly all living quadrupeds can rear up onto their hind limbs: even tortoises can do it when motivated by a tasty morsel. But very few have the right build or the balancing ability to walk on two legs.

And yet there are surprising exceptions. Who would guess, looking at pangolins, that they can walk bipedally? Yet they do, naturally in the wild. We can't tell for sure, but it doesn't seem impossible that *Diplodocus* or a related sauropod might have done something similar.

- Illustration of the skeleton of a hypothetical bipedal Apatosaurus *by Scott Hartman*



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