March 6, 2013, 5 p.m.

How sauropods like Argentinosaurus lived with the problems of being huge

MIKE TAYLOR - Even by dinosaur standards, sauropods were stupidly huge. A big tyrannosaur or duck-bill might weigh seven or eight tonnes - like a big elephant. The biggest sauropods were ten times as heavy - the size of whales. But unlike whales, they supported that bulk on land.

Argentinosaurus was among the very biggest of the sauropods - but how do we know how big it was? Unlike better-known mid-sized sauropods like *Diplodocus* and *Camarasaurus*, there is no complete skeleton. The best specimen consists of six vertebrae from the torso, a partial sacrum (the vertebrae that the hips fused to), a rib and one limb bone. That's not much to go on.

Fortunately, these fossils are enough to tell us what kind of sauropod it is - a primitive titanosaur. There are related sauropods in much better shape. By comparing the incomplete *Argentinosaurus* remains with complete skeletons of its relatives *Saltasaurus* and *Giraffatitan*, we estimate its weight at 70–80 tonnes. And it's unlikely that this specimen was as big as *Argentinosaurus* got.

As if moving 70-tonne bodies around on land wasn't challenge enough, sauropods made things even more difficult by having very long necks: up to 15 metres in *Supersaurus*, which is more than six times as long as that of the world-record giraffe.

It's hard to calculate the weight of such a neck, but a reasonable guess would be about six tonnes. That's equivalent to suspending an elephant several metres in front of the torso. The huge size and bizarre shape of sauropods posed all sorts of problems that modern animals don't have to deal with. How could they stay alive long enough to reach such sizes? How could they eat enough to sustain such bodies? How could their limbs support their weight, even when moving? How could the long necks be held up? Here are the answers.

Grow up fast
As recently as 20 years ago, some scientists argued that sauropods must have lived for centuries to reach huge sizes. More recently, analysis of the microstructure of dinosaur bones has shown that they grew much faster. Even giant sauropods reached adult size within two or three decades.

Good digestion
Elephants famously need to eat for 12 hours every day to keep their bodies stoked. So you might think that a 70-tonne animal would need more than 24 hours per day! But sauropods sidestepped this problem by skipping the time-consuming process of chewing.

Sauropod teeth were for biting, not munching, and they must have swallowed cropped vegetation whole. As well as speeding up feeding, this also reduced the weight of their heads, allowing the necks to be less heavily muscled.

Mammals chew because food can be digested faster if it's reduced to small particles first – so why didn't sauropods do the same?

Recent studies show that all available nutrients are extracted from food after three days in the gut,

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regardless of particle size. Sauropods were big enough to have very long guts that retained food for at least this long, so there would have been no advantage in chewing even had they been able.

Have an elephant's legs

The limb-bones of sauropods were optimised for a stiff-legged upright gait that would have minimised bending forces. Like those of elephants, these bones had thick walls and small or absent marrow cavities, making them stronger in compression.

It used to be believed that sauropods spent much of their time in water to buoy up their bodies, but multiple lines of evidence show that they did not. Their limbs were optimised for walking on land, their feet were compact and unsuited for marshy terrain, trackways show that they were good walkers, and their fossils are often found in sediments deposited in semi-arid environments.

Lighten up

Finally, sauropod necks, like those of all animals, were held up by a combination of ligament and muscle. But they were lightened in several ways. Most importantly, the neck vertebrae were air-filled - in some cases reducing their weight to only one ninth that of solid bone.

Air sacs also ran through the muscles and under the skin, just as in birds. Muscles that moved neck vertebrae were attached to long neck ribs, allowing the muscles to be closer to the torso, so their weight didn't act so far from the body.

All in all, sauropods were superbly engineered for living large.

- 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.

- Composite photo of blue whale, Brachiosaurus, elephant and humans: Matt Wedel

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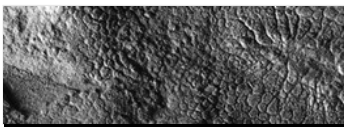

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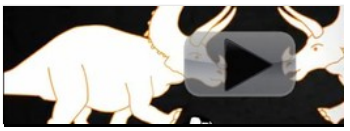

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