Big Sauropods—Really, Really Big Sauropods

By Gregory S. Paul

For the last quarter century an array of newly discovered sauropods—*Supersaurus, Ultrasauros,* and *Seismosaurus*—have competed for the title of the world's largest dinosaur. These have been big, but not much more so than other well-known sauropods. A few sauropods truly dwarf all the others. One of them is new, but the biggest of all was discovered over a century ago, lost, and nearly forgotten.

First we go to Argentina, home of enormous Late Cretaceous titanosaurs, such as "Antarctosaurus" gigantus, which supplied a 2.3m long femur, the largest limb bone yet described in a published paper. Jose Bonaparte recently described another incomplete behemoth, *Argentinosaurus huinculensis.* The tibia of this colossus is 1.55m long, and the estimated femur length is 2.4m. Even more impressive are the fragmentary trunk vertebrae, which must have been 1.5m tall (over 5 feet). The length of the trunk was some 7m, about twice as long as the trunks of typical sauropods. Titanosaurs were also very "plump" sauropods—the ilia of their hips flared strongly to the sides to support an unusually broad gut. *Antarctosaurus* and *Argentinosaurus* probably weighed 80 to 100 tonnes, nearly twice as much as supersaurs and ultrasaurs.

A bone found in 1878 from the Late Jurassic sediments of Garden Park in Colorado may outclass even the titanosaurs. The bone is a 1.5m tall central part of a vertebra from the trunk just in front of the hips. Unfortunately, the bone was lost, either before or during the transfer of Edward Drinker Cope's private collection to the American Museum of Natural History in New York. When Cope described and named the bone *Amphicoelias fragillimus* in 1878, he commented that in "the extreme tenuity of all its parts, this vertebra exceeds those of [sauropods] already described." He calculated the complete height of the vertebra as at least six feet, and estimated that the femur should have been twelve feet long. At a Denver conference on the Morrison Formation in May of 1994, John McIntosh suggested that the femur was over ten feet long. If anything, these are conservative estimates!

Also found at Garden Park were a few bones of *Amphicoelias altus.* The spines of the last trunk vertebrae are unusually narrow in both sauropods, although *A. fragillimus* is much larger. *A. altus* appears to have been a lightly built sauropod closely related and similar in size to *Diplodocus.* The femur of *A. altus* is exceptional for its length and slenderness.

Using the complete vertebra of *A. altus* as a guide, the height of the big *A. fragillimus* vertebrae was at least 2.4 m, and could have been more than 2.6m (8' 6"!). *A. fragillimus* was 2.2 to 2.5 times larger than *A. altus* and *Diplodocus.* The implications of such dimensions are difficult to comprehend. Extrapolating the femur/vertebra ratio of *A. altus* to *A. fragillimus* results in a femur length of around 3.8 m. Hip height should have been about 9m (30'). If the total length/vertebra height ratio was similar to that of *Diplodocus,* then *A. fragillimus* was some 50m (approaching 170') long. Body mass should have been ten times higher than that of the smaller diplodocids, about 125 tonnes. By working with the figures the size estimates can be forced down about 10 to 20 percent, but the fact is that the size of the vertebra could support even higher estimates.

"Super-sauropods" could have brought down all but the biggest trees. The surprising slenderness of the giant *Amphicoelias* vertebra and the *Argentinosaurus* tibia suggests that even they were not close to the maximum size possible! Indeed, it is hardly likely that we have found the biggest sauropods, so species as heavy as 200 tonne blue whales cannot be ruled out. The skeletons alone of super-sauropods weighed about 20 to 30 or more tonnes (more than the biggest entire land mammals), so they were the most preservable and discoverable fossils ever. The scarcity of their remains therefore suggests that their populations were extremely low. This is contrary to the hypothesis that sauropods were energy-efficient reptiles with higher population densities than giant mammals. Besides, if 100 to 200 tonne sauropods had reptilian metabolisms, then their hearts would have done only about as much work as a big elephant's heart. It is difficult to see how such weak hearts could have oxygenated the fifty tonnes of skeletal muscles needed to carry and operate 125 tonnes of flesh and bones, or pumped blood at very high pressures all the way up the long necks. Enormous heart tissues burning as much oxygen as an entire elephant were called for, raising total metabolisms to whale-like levels. Consider that growing from a few to over a hundred thousand kilograms in a few decades meant that the biggest sauropods put on up to ten kilograms a day, a feat exceeded by only energetic whales calves fed great quantities of high nutrition-density milk.

To be a giant on land probably requires an animal to be an aerobically capable athlete. This may be why terrestrial low-energy reptiles have never exceeded a tonne in mass, and endothermic mammals and dinosaurs have. The reason sauropods grew five times bigger than land mammals cannot be attributed to their continuous growth—termination of growth and life almost coincide in bull African elephants. Differing modes of reproduction are probably responsible. Over an adult lifespan of forty years, the number of eggs laid by a sauropod was fifty to five hundred times higher than the number of calves dropped by an elephant. There have to be a lot of adult elephants to raise the few highly dependent young that they produce. Only a few super-sauropods, each eating as much as an entire elephant herd, could sustain a viable population simply by breeding like rabbits. Even if all the adults were lost, just a few juveniles needed to grow up and start things over again.

A July attempt by a team from the Denver Museum of Natural History, led by Kenneth Carpenter, to relocate the giant *Amphicoelias* quarry with ground penetrating radar was not successful, but it remains possible that more super-sauropod fossils will be found at Garden Park.

Dinosaur	Femur Length (m)	Last Trunk Vertebra Height (m)	Total Length (m)	Tonnes
Amphicoelias fragillimus	3.1-4.0*	2.2-2.6	40-60*	100-150
Argentinosaurus & Antarctosaurus	2.3-2.4*	1.5	30-35*	80-100
Brachiosaurus (=Ultrasauros)	2.1-2.4	0.8	20-25	30-50
Supersaurus			35-45*	40-50
Seismosaurus			30-34*	25-30
Apatosaurus	1.7-1.8	1.35	22-23	17-20
Camarasaurus	1.5-1.8	0.7-1.0	15-18	14-23
Mamenchisaurus	1.35	0.98	20.5	14
Amphicoelias altus	1.77	1.075		12
Barosaurus	1.5	1.1	28	12
Diplodocus	1.54	1.05	24.8	11
Omeisaurus	1.3	0.57	17.6	8.5

*Estimated

A Visual Guide to Super-Sauropods

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