How Dinosaurs Ran

Did the giants of the Mesozoic period lumber sluggishly, or were they formidable running machines? Techniques borrowed from modern physics and engineering may give us the answer

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Elephants do not prance and leap about like gazelles, and they cannot do so because of their size. Imagine how some dinosaurs, much more massive than any elephant, must have moved. Perhaps their legs were too weak to support their enormous weight, so they lived in lakes and depended on water to buoy them up, as some old pictures suggest. Or perhaps their limbs were strong enough to support them and they walked and ran like elephants—or some of the more athletic modern animals—despite their size.

Because the dinosaurs are extinct, we cannot confirm or refute any of these possibilities by direct observation, but we can get some answers by using methods taken from physics and engineering. Using information from these sciences and observation of wildlife today, we can understand some of the ways that dinosaurs may have moved.

An important piece of evidence is the fossil record, both from bones and from dinosaur tracks, which can be used to describe how agile or sluggish these giant animals were. The picture that emerges can tell us whether Triceratops—the horned quadruped—galloped or shuffled and whether Tyrannosaurus—the bipedal carnivorous king—could outmaneuver or outrun his Triceratops prey.

To understand how dinosaurs moved, we need information about modern animals—particularly about the effects of size differences on their movement. I had been researching the mechanics of running and jumping in frogs, dogs, kangaroos and other animals for several years, when I was invited to speak at a conference about the impact of size on animal locomotion. So I set out to develop a theory of running that would account for size.

One prediction I made involved stride length, the distance between successive footprints of the same foot. The faster animals run, the longer their stride. The hypothesis held that for similarly shaped animals, different animals would take strides in proportion to their leg length. Therefore, a graph of relative stride length (that is, stride length divided by leg length) plotted against speed would show a correlation between the two.

It soon occurred to me that I could use data I had collected to estimate the speed of dinosaurs from the stride lengths shown by their footprints. Rather surprisingly, great numbers of dinosaur footprints have survived as impressions in mud that turned to stone. These tracks show that dinosaurs walked with their feet directly under their bodies like mammals and birds, not sprawled out to either side in the manner of modern reptiles. Consequently, the relation between relative stride length and speed for mammals should also apply to dinosaurs.

DINOSAUR TRACKS provide a record of stride length and speed. A small, three-toed carnivore may have pursued a larger sauropod along this Texas trail. This pair of footprints was discovered by Ronald T. Bird at Paluxy Creek in 1944.

The largest-known footprints, with hind feet measuring 1.3 meters (about 4 feet) in diameter, have been found in Spain. Tracks of slightly smaller prints lie in other parts of the world—even in Yorkshire, England. The best known of the smaller prints—measuring 0.9 to 1.0 meter (about 3 feet) in diameter—were discovered in Texas. The size and shape of these footprints suggest that sauropods, huge long-necked, long-tailed herbivores, roamed this region. Three-toed bipeds similar to Tyrannosaurus made other tracks nearby. One famous trail shows that these two Texans met: a sauropod and a tyrannosaur-like biped traveled along the same path. Was this dramatic chase leading to a kill? Were the animals heaving themselves along slowly and with difficulty, or did they rush past at earth-shaking speeds?
Using stride lengths measured from these and similar trackways, as well as data collected from other mammals, I made my first efforts to infer the speed of dinosaurs. Since leg length can be estimated from the size of the footprints—footprints should be about one quarter of leg length—relative stride length could also be calculated. And once relative stride length was established, I used the graph of previously collected data to find the corresponding speed. The results may not be very accurate, however, because the data points on the graph show a fair amount of scatter and because we are using data from modern animals to estimate speeds for dinosaurs.

By this account, the speed of the large dinosaurs was unimpressive. All known footprints of large sauropods seem to show speeds of about one meter per second, a slow walking speed for humans that seems painfully slow for animals with three-meter hind legs. None of the footprints of very large bipedal dinosaurs show speeds above 2.2 meters per second (about 5 miles per hour), the pace of a fast human walk.

Although most of the footprints of big dinosaurs seem to show walking speeds, many footprints of smaller ones record running. The fastest tracks were made in Texas by a biped of probably a little more than 1000 pounds, roughly the mass of a racehorse, and by another somewhat smaller one. Both sets of footprints indicate a speed of 12 meters per second (about 25 miles per hour). This is higher than the peak speed of 11 meters per second reached by the best human sprinters, but well below the speeds of 15 to 17 meters per second (about 35 miles per hour) at which horse races are generally won.

The lack of running footprints of huge dinosaurs, however, does not show that they could not run but merely that they usually walked—at least on surfaces in which footprints were likely to be preserved. If you were to go out on a snowy day, for example, and measure human footprints, you would probably find only short strides, indicating walking speeds, but you would be wrong to conclude that people cannot run. Clearly, a different approach was needed to judge how athletically large dinosaurs could have moved when they really tried.

**STRIDE LENGTH** is the distance between two successive prints from the same foot. *Compsognathus*, a carnivore the size of a modern-day chicken, is depicted here.