DINOSAUR MOTION

Did Saurian Predators Fold Up on Turns?

Want to run like a dinosaur? Step into David Carrier's lab at the University of Utah, Salt Lake City, and strap yourself into his dinosuit. With 2 meters of weighted planks balanced on your hips, you'll get a feel for how a carnivorous dinosaur called a theropod might have maneuvered its stretched-out frame.

Carrier's team has already strapped several students into the contraption and put them through their paces. Their conclusion: Large Mesozoic predators weren't track stars. In an upcoming issue of the *Journal of Experimental Biology*, Carrier and graduate students Rebecca Walter and David Lee argue that massive tails and bulky heads would have kept theropods from turning on a dime—and that could have made rugged terrain inaccessible or hindered their ability to catch prey. Other experts aren't so sure, noting that theropods excelled as top predators for 120 million years and differed from their human stand-ins in key ways. But even skeptics say that Carrier's creative approach to dino motion has given them things to consider. "This is one of those bits of incredibly delightful goofiness that I wish I'd thought of," says Jim Farlow, a paleontologist at Indiana University–Purdue University, Fort Wayne.

Carrier, a comparative physiologist, suspected that rotational inertia might have caused problems for theropods. When a graduate student joked about testing the idea by dressing up like Barney, a purple dinosaur on a children's TV show, Carrier immediately hit on an idea: Design a pack that would give a person the mass distribution of a similar-sized theropod. He and his crew measured the rotational inertia of a small plastic toy model of *Allosaurus*, then scaled it up to a 90-kilogram human. By constructing a backpack with horizontal beams jutting fore and aft, they increased the rotational inertia more than ninefold, into theropod territory.

The first test was to turn while jumping up in the air, à la basketball star Michael Jordan. Five grad students recruited from the biology department found that they could twist only 20% as far as when they jumped while wearing control backpacks with weights close to their backs. Next, nine grad students ran at top speed through a flat slalom course of six 90-degree turns. Their average velocity dropped to 77% of control runs. When the students had to place their feet in particular spots—to mimic turning on rough ground—their time fell to 65%. "It makes a tremendous difference," Carrier says. "As soon as you put the pack on, you're clearly compromised."

Large theropods would have suffered even more, Carrier says. Rotational inertia increases much faster than muscle strength as animals get larger, increasing the chance of stumbling, among other liabilities. "Those animals would have a hard time changing directions," Carrier says, "and the problems would have gotten worse and worse as they got bigger."

Faced with such challenges, Carrier suggests, theropods compensated by repeatedly evolving shorter tails, smaller bodies, porous vertebrae, and even fewer teeth. More controversially, Carrier and his colleagues propose that theropods rarely walked or ran with their trunks and tails horizontal, as most paleontologists imagine. Instead, the Utah scientists envision the back arched, tail raised high, and forelimbs tucked back against the body. This jackknife posture would reduce rotational inertia by half, they say.

Not everyone is ready for such an about-face. "It's a completely impractical way of walking," says dino-locomotion expert Don Henderson of Johns Hopkins University in Baltimore. The proposed posture, he argues, would reduce the mechanical advantage of the caudifemoral muscle, which attached to the tail and helped power the legs. Several other features of large theropods would have helped them deal with their rotational inertia, he says. Large toes and broad feet provided added leverage to tilt the body, and weight concentrated over the hips kept them relatively more compact than smaller dinosaurs.

New twist. Experiments with a weighted frame show that some large dinosaurs had trouble turning.

And then there's the tail. Farlow points out that theropod tails, unlike lumber, could bend. Used as counterweights, he says, tails could have helped the dinosaurs tack more sharply. Carrier concedes that the tail is important—he decided not to rig up a motor-driven tail to prevent injuries—but says that it would have helped a dinosaur reorient its head by less than 60 degrees. Despite qualms, some other heads are beginning to turn. "They've made a good first stab at estimating turning performance," says John Hutchinson, a graduate student studying theropod locomotion at the University of California, Berkeley. "That's a step forward." **–ERIK STOKSTAD**

PALEOECOLOGY

How Grasses Got the Upper Hand

A slow dwindling of carbon dioxide in the atmosphere during the past 100 million years is the common explanation for the sudden worldwide surge in the abundance of tropical and subtropical grasslands 7 million or 8 million years ago. As CO_2 levels slid below a critical threshold in the late Miocene epoch, the story goes, tropical grasses seized the ecological advantage from shrubs and trees because the molecular machinery by which grasses photosynthesize is particularly well adapted to taking up the essential gas at low levels. The rise of the grasses might then have driven the evolution of hoofed mammals well adapted to graze on them.

But loose ends keep appearing. The latest, as reported on page 1647 of this issue, points to moisture, not just CO_2, as pivotal in the emergence of low-latitude grasslands. It also clouds the crystal ball for researchers trying to get a handle on future global change.

The new study, by organic geochemist Yongsong Huang of Brown University in Providence, Rhode Island, and colleagues, compares the relatively recent ecological histories around two lakes to see which plants gained the upper hand. Since the peak of the last ice age, the two regions have experienced the same increase in atmospheric CO_2 levels but very different climate changes.

One of the two lakes, Alta Babícora in the northern Mexico state of Chihuahua, was brimming with water 13,000 to 21,000 years ago, judging by microfossils found in a mud core recovered from the lake bottom. From the same mud, Huang and his colleagues isolated distinctive long-chain hydrocarbons derived from the leaf wax of land plants carried into the lake. By measuring the carbon isotopic composition of these leaf hydrocarbons, they were able to gauge the ratio of land plants like shrubs and trees to tropical grasses.

The tropical grasses tend to use a different photosynthetic process: the so-called C_4 pathway rather than the C_3 pathway. It's the C_4 pathway that lets grasses concentrate CO_2 within their cells and outcompete C_3 plants for this essential compound. As a result, C_4 plants also produce organic matter richer in the heavier carbon isotope than do shrubs and trees. About 18,000 years ago, a relatively wet climate around Alta Babícora supported a

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