A
gama lizards jump quite well, and have a remarkable ability to land safely. In a paper published on Nature's website today, Libby et al.¹ describe a study in which they filmed agamas jumping from a horizontal platform to a vertical wall. The lizards used mid-air tail movements to ensure that their trunk was tilted at an appropriate angle for landing as they approached the wall.

The manoeuvre depends on the principle of conservation of angular momentum, which states that the angular momentum of a system remains constant unless external torques act on it. For example, some tightrope walkers carry a balancing pole. By tilting the pole, the performer can make his or her body lean in the opposite direction to that tilt; any change of angular momentum of the pole must be matched by an opposite change of angular momentum of the body, to keep the overall angular momentum constant (Fig. 1a). Small movements of the pole can therefore keep the performer's centre of mass where it needs to be, vertically above the rope. A long, slender pole works better than a short, thick one, because it has a larger moment of inertia for the same weight (the angular momentum of a body is its angular velocity multiplied by its moment of inertia). This simple explanation assumes that any transverse movements of the centre of mass are so small that the moment of body weight about the rope is negligible.

In their study, Libby et al. found that if a lizard needed to tilt its trunk 'nose-up' during a jump to ensure that it landed correctly on a vertical surface, it bent its long, slender tail upwards (Fig. 1b). This, for example, gave the tail clockwise momentum and the trunk equal anticlockwise momentum, leaving the total angular momentum unchanged, as the conservation principle requires. To find out whether a lizard could adjust its tail movements to compensate for errors at launch, the authors put a slippery surface on the take-off platform for some of the trials. They observed that if a lizard's foot skidded, the angle of the body at take-off was affected, but the animal corrected the error using an appropriate tail movement.

Libby et al. used a mathematical model to confirm that their explanation of tail control worked quantitatively. As a further check, they built a delightful toy: a wheeled robot with a tail, which leapt like a ski jumper from a ramp. During each jump, the front wheels of the robot left the ramp first and started falling while the rear ones were still on the ramp, causing the robot to tilt nose-down. But the machine corrected the angle of its body before landing using tail movements that were controlled by feedback from a gyroscope. The robot compensated for its imperfect launch posture brilliantly, even better than did the lizards.

As with all good research, Libby and colleagues’ findings raise new questions. The authors considered a lizard's use of its tail as a two-dimensional problem: they considered only the pitch of the body (whether its nose was up or down). But can the tail also be used to adjust the angle of yaw (turning to left or right) and roll? Pitch is paramount when jumping onto a vertical wall, but jumping between irregularly shaped rocks or branches would require adjustments in three dimensions. The same group has previously considered all three dimensions in a paper² on body-righting responses of falling geckos, but there are opportunities for more quantitative work along these lines.

Apart from lizards, Libby et al. cite several examples of animals that exploit the moment of inertia of an appendage, including lemurs, kangaroo rats and cats. The authors go on to suggest that some dinosaurs may have jumped, using their tails as agamas do to control the angle of the body. Any dinosaurs that did this, however, must have been relatively small. Very large animals cannot jump far because — assuming that their anatomy is geometrically similar to that of their smaller kin — their weights are proportional to the cube of their lengths, whereas the strengths of their bones and muscles are proportional only to their lengths, whereas the strengths of their bones and muscles are proportional only to their lengths squared. Horses and elands (a very large species of antelope) are, at around 500 kilograms each, among the largest animals that can jump well. Calculations based on measurements of dinosaur bones³ and on the estimated dimensions of their muscles⁴ show that large dinosaurs cannot have been very agile.

So is there any evidence that smaller dinosaurs jumped? The carnivorous dinosaur Deinonychus is estimated to have had a mass

Figure 1 | Conservation of angular momentum. a, When a tightrope walker rotates his balancing pole clockwise, his body tilts anticlockwise, in accordance with the principle of conservation of angular momentum. b, Libby et al.¹ report that leaping agama lizards similarly bend their tails clockwise in mid-air, to tilt their bodies anticlockwise.
of about 70 kilograms — in the size range of leopards, and well within the feasible range for jumping. Some fossil evidence has been interpreted\(^5\) as suggesting that *Deinonychus*, hunting in packs, may have preyed on dinosaurs much larger than themselves. Although this suggestion has been challenged\(^6\), it has been widely assumed that *Deinonychus* leapt onto the backs and flanks of their victims, using enormous claws to get a firm grip\(^7\). Similarly, lions and other big cats use their sharp claws to grip the hide of their prey, while using their teeth to attack the vulnerable structures of the throat.

There are several drawings on the Internet showing *Deinonychus* in mid-air, jumping onto large prey. Some of the drawings show the animal jumping improbably high, but it is pleasing to see that several of them show the tail swung upwards in the manner used by agamas, as reported by Libby and colleagues\(^1\).

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