EXPLORE THE ISSUE BEING INVESTIGATED

Why Some Lizards Take a Deep Breath

Sometimes, what is intended as a straightforward observational study about an animal turns out instead to uncover an odd fact, something that doesn't at first seem to make sense. Teasing your understanding with the unexpected, this kind of tantalizing finding can be fun and illuminating to investigate. Just such an unexpected puzzle comes to light when you look very carefully at how lizards run.

A lizard runs a bit like a football fullback, swinging his shoulder forward to take a step as the opposite foot pushes off the ground. This produces a lateral undulating gait, the body flexing from side to side with each step. This sort of gait uses the body to aid the legs in power running. By contracting the chest (intercostal) muscles on the side of the body opposite the swinging shoulder, the lizard literally thrusts itself forward with each flex of its body.

The odd fact, the thing that at first doesn't seem to make sense, is that running lizards should be using these same intercostal chest muscles for something else.

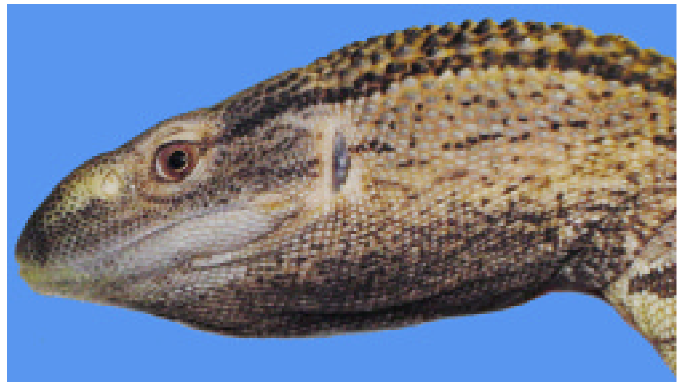
At rest, lizards breathe by expanding their chest, much as you do. The greater volume of the expanded thorax lowers the interior air pressure, causing fresh air to be pushed into the lungs from outside. You expand your chest by contracting a diaphragm at the bottom of the chest. Lizards do not have a diaphragm. Instead, they expand their chest by contracting the intercostal chest muscles on both sides of the chest simultaneously. This contraction rotates the ribs, causing the chest to expand.

Do you see the problem? A running lizard cannot contract its chest muscles on both sides simultaneously for effective breathing at the same time that it is contracting the same chest muscles alternatively for running. This apparent conflict has led to a controversial hypothesis about how running lizards breathe. Called the axial constraint hypothesis, it states that lizards are subject to a speed-dependent axial constraint that prevents effective lung ventilation while they are running.

This constraint, if true, would be rather puzzling from an evolutionary perspective, because it suggests that when a lizard needs more oxygen because it is running, it breathes less effectively.

Dr. Elizabeth Brainerd of the University of Massachusetts, Amherst, is one of a growing cadre of young researchers around the country that study the biology of lizards. She set out to investigate this puzzle several years ago, first by examining oxygen consumption.

Looking at oxygen consumption seemed a very straightforward approach. If the axial constraint hypothesis is correct, then running lizards should exhibit a lower oxygen consumption because of lowered breathing efficiency. This is just what some of her colleagues found with green iguanas (*Iguana iguana*). Studying fast-running iguanas on treadmills, oxygen consumption went down as running proceeded, as the axial constraint hypothesis predicted.



Some species of lizard breathe better than others. The savannah monitor lizard *Varanus exanthematicus* breathes more efficiently than some of its relatives like the iguana shown here. The monitor lizard breathes by pumping air into its lungs from the gular folds over its throat. Iguanas don't have these gular folds.

Unexpectedly, however, another large lizard gave a completely different result. The savannah monitor lizard (*Varanus exanthematicus*) exhibited *elevated* oxygen consumption with increasing speeds of locomotion! This result suggests that something else is going on in monitor lizards. Somehow, they have found a way to beat the axial constraint.

How do they do it? Taking a more detailed look at running monitor lizards, Dr. Brainerd's research team ran a series of experiments to sort this out. First, they used videoradiography to directly observe lung ventilation in monitor lizards while the lizards were running on a treadmill. The X-ray video images revealed the monitor's trick: the breathing cycle began with an inhalation that did not completely fill the lungs, just as the axial constraint hypothesis predicts. But then something else kicks in. The gular cavity located in the throat area also fills with air, and as inhalation proceeds the gular cavity compresses, forcing this air into the lungs. Like an afterburner on a jet, this added air increases the efficiency of breathing, making up for the lost contribution of the intercostal chest muscles.

The Experiment

Brainerd set out to test this gular pumping hypothesis. Gular pumping occurs after the initial inhalation because the lizard closes its mouth, sealing shut internal nares (nostril-like structures). Air is thus trapped in the gular cavity. By contracting