Alligators hint at what life may have been like for dinosaurs

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During the last 540 million years, the earth's oxygen levels have fluctuated wildly. Knowing that the dinosaurs appeared around the time when oxygen levels were at their lowest at 12%, Tomasz Owerkowicz, Ruth Elsey and James Hicks wondered how these monsters coped at such low oxygen levels. But without a ready supply of dinosaurs to test their ideas on, Owerkowicz and Hicks turned to a modern relative: the alligator.

'We knew testing the effects of different oxygen levels would work with

alligators,' Owerkowicz explains, 'because crocodilians have survived in their basic shape and form for 220 million years. They must be doing something right to have survived the oxygen fluctuations.' Choosing to start at the beginning of alligator development, the trio decided to try incubating alligator eggs at different oxygen levels, to find out how the youngsters grew and developed and publish their results on April 17 2009 in The Journal of Experimental Biology.

Receiving newly laid alligator eggs from Elsey at the Rockefeller Wildlife Refuge, Owerkowicz divided the eggs into groups incubated at 12% (low) oxygen, 21% (normal) oxygen and 30% (high) oxygen, and waited to see what would happen. After almost 10 weeks of waiting, the eggs began hatching and Owerkowicz could see that there were no obvious differences between the alligators that developed in normal and high oxygen atmospheres.

But he was in for a shock when the low oxygen level hatchlings began to emerge. The tiny alligators' bellies were enormously swollen. They had failed to absorb all of the egg yolk food supply, leaving them with huge yolk-distended bellies. In some cases the bellies were so big that the animals' legs could not reach the ground, and the alligators had to sit around until they had burned off the yolk and could begin moving. Owerkowicz suspects that there was not enough oxygen for the developing embryos to consume the yolk.

The low oxygen level youngsters' organs were much smaller too, all except the heart, which was relatively large, presumably to maximise use of the youngsters' limited oxygen supplies. Owerkowicz admits that he had thought that the low oxygen newborns' lungs would also be enlarged, to compensate for the poor oxygen supply, but they were not, probably because the incubating youngsters do not use their lungs and instead obtain their oxygen through blood vessels in the egg's membrane.

Next Owerkowicz was curious to see how the alligators performed after 3 months in their respective atmospheres. Checking the reptiles' breathing and metabolic rates, it was clear that the animals in the high oxygen atmosphere were breathing much less than the normal and low oxygen animals, probably because animals in the 30% oxygen atmosphere breathe in more oxygen per lungful, translating into a significant energy saving, which the reptiles could invest in growth. And when Owerkowicz checked the size of the 3 month old low oxygen youngsters' lungs, he could see that they had caught up with his expectations and were larger than those of the normal oxygen alligators. The alligators' lungs were enlarged to compensate for the low oxygen supply, allowing the alligators to increase their metabolic rates, but not as much as the normal or high oxygen alligators.

Owerkowicz admits that although his results can't tell us what life was like for his alligators' prehistoric predecessors, it is clear that 'their growth and metabolic patterns would have been significantly different,' he says.

More information: Owerkowicz, T., Elsey, R. M. and Hicks, J. W. (2009). Atmospheric oxygen level affects growth trajectory, cardiopulmonary allometry and metabolic rate in the American alligator (Alligator mississippiensis). J. Exp. Biol. 212, 1237-1247. http://jeb.biologists.org

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