The eyes have it: Dinosaurs hunted by night

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Velociraptor mongoliensis was a nocturnal carnivore. Credit: Lars Schmitz, UC Davis.

The movie Jurassic Park got one thing right: Those velociraptors hunted by night while the big plant-eaters browsed around the clock, according to a new study of the eyes of fossil animals. The study will be published online April 14 in the journal *Science*.

This conclusion overturns the conventional wisdom that dinosaurs were active by day while early mammals scurried around at night, said Ryosuke Motani, professor of geology at UC Davis and co-author of the paper.

"It was a surprise, but it makes sense," Motani said.

The research is also providing insight into how ecology influences the evolution of animal shape and form over tens of millions of years, according to Motani and collaborator Lars Schmitz, a postdoctoral researcher in the Department of Evolution and Ecology at UC Davis.

Motani and Schmitz, a former graduate student of Motani's, worked out the dinosaur's daily habits by studying their eyes.

Dinosaurs, lizards and birds all have a bony ring called the "scleral ring" in their eye, a structure that is lacking in mammals and crocodiles. Schmitz and Motani measured the inner and outer dimensions of this ring, plus the size of the eye socket, in 33 fossils of dinosaurs, ancestral birds and pterosaurs. They took the same measurements in 164 living species.

The pterosaur *Scaphognathus crassirostris* was a day-active, flying archosaur. Scleral ring highlighted. Credit: Lars Schmitz/UC Davis.

Day-active, or diurnal, animals have a small opening in the middle of the ring. In nocturnal animals, the opening is much larger. Cathemeral animals -- active both day and night -- tend to be in between.

The size of these features is affected by a species' environment (ecology) as well as by ancestry (phylogeny). For example, two closely related animals might have a similar eye shape even though one is active by day and the other by night: The shape of the eye is constrained by ancestry.

Schmitz and Motani wrote a computer program to separate the "ecological signal" from the "phylogenetic signal." The results of that analysis are in a separate paper published simultaneously in the journal Evolution.

By looking at 164 living species, the UC Davis team was able to confirm that eye measurements are quite accurate in predicting whether animals are active by day, by night or around the clock.

They then applied the technique to fossils from plant-eating and carnivorous dinosaurs, flying reptiles called pterosaurs, and ancestral birds.

The measurements revealed that the big plant-eating dinosaurs were active day and night, probably because they had to eat most of the time, except for the hottest hours of the day when they needed to avoid overheating. Modern megaherbivores like elephants show the same activity pattern, Motani said.

This plant-eating dinosaur, *Protoceratops andrewsi*, was active day and night, like many other herbivorous dinosaurs. Credit: Lars Schmitz, UC Davis.

Velociraptors and other small carnivores were night hunters, Schmitz and Motani showed. They were not able to study big carnivores such as Tyrannosaurus rex, because there are no fossils with sufficiently well-preserved scleral rings.

Flying creatures, including early birds and pterosaurs, were mostly day-active, although some of the pterosaurs -- including a filter-feeding animal that probably lived rather like a duck, and a fish-eating pterosaur -- were apparently night-active.

The ability to separate out the effects of ancestry gives researchers a new tool to understand how animals lived in their environment and how changes in the environment influenced their evolution over millions of years, Motani said.

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