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The DINOSAURS OF ARCTIC ALASKA

Seventy-five million to 70 million years ago, a group of hardy dinosaurs thrived in the harsh climate of what is now northern Alaska

By Anthony R. Fiorillo

A few more sweeps with the whisk broom,

and the bone at my knees suddenly came into focus. I was looking at the snout of a *Pachyrhinosaurus*, a particularly odd horned dinosaur, a rare relative of *Triceratops*. It was not the first, or even the second, fossil of this creature found in Alaska, but I could already see parts of this skull that were not preserved on the others. Continued excavation at the site—with picks and shovels supplementing our whisk brooms—yielded the bones and teeth of at least three other dinosaur species. It would take another year for me to realize we were also crawling over seven more skulls of *Pachyrhinosaurus*. They were close in age and had probably died together in a flood or other catastrophe. This grouping was the first evidence that horned dinosaurs north of the Arctic Circle behaved gregariously.

I had come to this remote spot on a bluff overlooking the Colville River in the summer of 2002 with colleagues from the

DOMINANT PREDATOR in late Cretaceous Alaska was *Troodon*. This twoto three-meter-long dinosaur viewed the world through unusually large eyes—a feature that may have contributed to its hunting success during the long months of twilight above the Arctic Circle. Dallas Museum of Natural History, Southern Methodist University and the University of Alaska to excavate the skull of a *Pachyrhinosaurus* I had found the previous year. The site had originally been discovered by researchers from the University of Alaska, and now, almost a decade later, we were beginning to think it might contain a huge and valuable accumulation of dinosaur fossils.

No one has yet excavated a complete dinosaur skeleton from this site or anywhere else in Alaska. Nevertheless, my group and other paleontologists have been able to identify from partial skeletons, isolated bones, teeth and fossil footprints eight types of dinosaurs that lived as contemporaries in the far north [*see illustration on pages 88 and 89*]. All eight date to the Cretaceous period, which lasted from 145 million to 65 million years ago. Most come from just the last few million years of the period, 75 million to 70 million years ago, some five million years before the famous mass demise of the planet's dinosaurs.

Our work is still in the early stages, but already we have begun to fill in some details about what kind of dinosaurs lived at the top of the world millions of years ago and how they survived there.

The Cast of Characters

FOUR OF THE SPECIES ate plants, and four others, called theropods, preyed on the plant eaters and other creatures. By far the richest area of the state for remains of both herbivores and predators is the northern part, referred to as the North Slope. The duck-billed hadrosaur *Edmontosaurus* earns the prize for the most common type there and so is the best characterized. Hadrosaurs—large, plant-eating dinosaurs—also go by the name "duck-bills" because they had broad, flat mouths; in contrast to ducks, however, they had hundreds of teeth that could grind the tough plants they fed on. They could stand on their back legs to reach overhead foliage, although they traveled on all fours, probably in a rocking gait, because their rear legs were longer than their front.

Many hadrosaurs in other parts of the world had head ornamentations, or crests, but *Edmontosaurus* did not. Weighing in at between 3,000 and 4,000 pounds, *Edmontosaurus* ranks among the largest of the hadrosaurs found in North America. Like other hadrosaurs, *Edmontosaurus* were social animals that gathered in herds, as evinced by their bones,

<u>Overview/Arctic Dinos</u>

- Over the past 20 years paleontologists have discovered that northern Alaska was home to a population of dinosaurs.
- So far the scientists have found eight species that lived there 75 million to 70 million years ago.
- These creatures must have had adaptations that allowed them to survive the extended months of darkness and cold; clues about these special characteristics are beginning to emerge.

which have been found in piles at various places in northern Alaska as though groups of them had died in a flash flood.

Every dinosaur that has been discovered thus far in Alaska has also been found elsewhere in western North America, so we cannot point to a distinct Alaskan dinosaur. We find fewer species of dinosaurs in these northern latitudes, however. This pattern of decreased biodiversity with increased latitude follows the trend seen in modern animal populations and, as it is today, may be a function of the limited resources available in the far north.

Alaska was not the only surprising home to dinosaurs. In the southern polar region, Judd Case of St. Mary's College of California and his colleagues are finding a record of dinosaurs in rocks of similar age. These researchers have uncovered fragmentary remains of theropods, hadrosaurs and several other kinds of dinosaurs. Patricia Vickers-Rich and Thomas Hewitt Rich of Monash University have identified dinosaurs that lived near the South Pole during a much earlier period [see "Australia's Polar Dinosaurs," SCIENTIFIC AMERICAN, July 1993].

How Did They Get There?

HOW DID DINOSAURS find themselves at the planet's northern extreme? More than likely they came from Asia, because ancestral forms of almost all the Cretaceous dinosaur families found in North America existed in Asia. Most paleontologists believe that some of these dinosaurs migrated across a land bridge exposed by a drop in sea level where the Bering Sea sits today [see box on opposite page]. The configuration of continental plates during the Cretaceous suggests that the earliest these plates were in position to serve as a land bridge was approximately 100 million years ago; the land bridge may have been exposed as many as three times during the period. Some of the immigrants probably just stayed in the far north because the environment there supplied their needs; others headed south. One species, though, seems to have taken a different route. Alamosaurus, a plant-eating dinosaur roughly 20 meters in length, apparently arrived by a southerly migration path-remains of its ancestors are found on the continents of South America and Africa.

Alaska is built of enormous geologic blocks, some of which originated far from their present location. During the Cretaceous, however, many of these blocks of land were near their current latitudinal position or higher. Thus, the dinosaur fossils found in Alaska were not posthumously hijacked from distant climes and brought there on moving plates: they lived in the high latitudes during the Cretaceous. Did they stay there all year? And if so, how did they manage it?

Coping with Cold

ANSWERING THAT QUESTION requires knowledge of the climate in Alaska some 75 million to 70 million years ago. True, the world was warmer then, but the climate in the highlatitude lands was still challenging, with cold, snowy winters and several months of darkness. Climatological data from fossil pollen, leaves and wood indicate that the Cretaceous forests

Dinosaurs at the Top of the World

During the Cretaceous period, some 75 million years ago, continental landmasses (*orange regions in inset at bottom left*) occasionally included a bridge of land, or isthmus, across what is today the Bering Strait. Dinosaurs probably walked across this stretch of land from Asia to North America. Some settled in the far north; others headed south.

In present-day Alaska the author and other paleontologists search for the fossil remains of the creatures that made their home so close to the North Pole. One of the richest sites for bones is Liscomb Quarry (*top right*), where finds include a group of juvenile duck-billed dinosaurs, or hadrosaurs (*bones at bottom right*), which probably died together, perhaps in a flash flood. Footprints of a small predatory dinosaur (*middle right*) from a nearby site on the Kaolak River appear white because of a silicone compound that is used to mold the ancient imprints. Another footprint (*bottom center*)—from the Aniakchak National Monument in southern Alaska—was molded and contoured to allow the scientists to identify and study it.



of northern Alaska consisted of a mixed canopy that included deciduous conifers with an understory of flowering plants, ferns and cycads. Today mixed coniferous forests occupy a wide but well-defined range of climates with mean annual temperatures from three to 13 degrees Celsius (37 to 55 degrees Fahrenheit), suggesting that the average yearly temperature for northern Alaska during the Cretaceous was similar.

One of the striking aspects of the modern Arctic is the angle of sunlight and the length of the day—commonly, though mistakenly, referred to as six months of daylight and six months of night. In actuality, north of the Arctic Circle, darkness occupies a longer and longer part of each day until the winter solstice (December 22), when the sun does not rise. During the Cretaceous, northern Alaska was even farther north than it is today, and so the dinosaurs that lived there would have needed mechanisms to cope with both the cold and the dark.

We do not know the full explanation of how they survived. It seems unlikely that a 10-meter-long (35-foot-long) hadrosaur dug a hole in the ground and went into hibernation. But during times of environmental stress, some animals can lower their



ALASKA circa 75 million years ago. Four plant-eating species (black labels at right) and four predators (red labels) foraged and hunted in the ancient landscape dotted with bald cypress and metasequoia-type trees. The snow-dusted mountains rising in the background are the ancestral Brooks Range. At the lower right a bird (Hesperornis) flees the small predatory Saurornitholestes.



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Serendipity in Storage

In 1961 the late Robert L. Liscomb, a geologist for Shell Oil Company, found a handful of bones of a duck-billed dinosaur, *Edmontosaurus*. These bones are extraordinarily well preserved, but because Liscomb and his colleagues were not vertebrate paleontologists, they identified the bones as much more recent fossil mammal bones. Liscomb died the following year in a rockslide, and his discoveries languished in storage. In the mid-1980s Henry Roehler and Gary Stricker of the U.S. Geological Survey reported various fragmentary dinosaurian remains, such as fossil skin impressions, from northwestern Alaska. Soon thereafter, the USGS came into possession of the original Liscomb collection of bones; Charles A. Repenning properly recognized that they were dinosaurs, and USGS field crews located the area where



Liscomb had done his initial work.

In the late 1980s the Universitu of California Museum of Paleontology and the University of Alaska Museum continued the fieldwork in this remote area, turning up finds that hinted at abundant remains of dinosaurs and other animals. Because of my interest in northern high-latitude dinosaur ecosystems, I was invited to participate in the project in 1998, and I have continued to make research trips to Alaska every year since, most recently expanding the search into several of the state's national parks. -A.R.F.

EXCAVATION by the author of a *Pachyrhinosaurus* skull in Liscomb Quarry.

metabolic rates enough to reduce their need for food; perhaps Arctic dinosaurs did something similar without reaching an official state of hibernation.

In trying to explain how hadrosaurs survived the harsh climate, the late Nicholas Hotton III of the Smithsonian Institution suggested that in winter they migrated thousands of kilometers to find forage, warmer temperatures and better light conditions. Subsequently, other researchers used modern caribou as an example of a long-distance migrant to support such theories about the migration of Arctic dinosaurs.

To investigate the likelihood that hadrosaurs migrated, Roland Gangloff of the University of Alaska Museum and I decided to see how well caribou work as an analogy for hadrosaurs. First we compared the body sizes of adults and ju-

ANTHONY R. FIORILLO, as far back as he can remember, has wanted to do only one of two things professionally: play center field for the New York Yankees or study dinosaurs. Much to the detriment of his parents' retirement plans, he studies dinosaurs. Fiorillo completed his Ph.D. in vertebrate paleontology at the University of Pennsylvania in 1989. In 1995, after stints at the Carnegie Museum of Natural History and the Museum of Paleontology at the University of California, Berkeley, he went to Dallas, where he is curator of earth sciences at the Dallas Museum of Natural History and an adjunct associate professor at Southern Methodist University. veniles in three Arctic herds of caribou. We discovered that juvenile caribou reach 80 to 85 percent of adult length and 53 to 74 percent of adult mass by the onset of migration.

Then we looked at the hadrosaur fossils. The cell structure of the bones clearly shows that the small hadrosaurs were juveniles at least one year old—not some form of a dwarf, highlatitude population. The lengths of the bones of the juveniles indicate that they were 27 to 37 percent of adult size and an estimated 11 percent of adult mass. The juvenile hadrosaurs, then, were relatively much smaller at one year of age than juvenile caribou are at the time of their seasonal migration. Therefore, on simple biomechanical grounds, it seems unlikely that hadrosaurs of the Arctic migrated great distances. We have not, however, discovered nests or eggs, which would of course clinch the argument that dinosaurs remained year-round at these high latitudes.

But if they stayed year-round, what did they eat during the cold winter months? We presume that the predators continued to eat meat, because the patterns of wear on their teeth suggest no change in diet during the year.

We do not know exactly what the herbivorous dinosaurs ate. *Edmontosaurus* offers an opportunity to speculate, however, because it had a range from northern Alaska all the way south to west Texas. Today another herbivorous vertebrate—the mountain sheep of North America—has a com-

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U.S. ARMY CHINOOK HELICOPTER lifts a plaster jacket containing parts of three *Pachyrhinosaurus* skulls from Kikak-Tegoseak Quarry. Out on a training mission, the helicopter's crew came to the aid of the scientists in removing the heavy load of fossils.

parable range. The diets of southern-latitude sheep are more restricted than northern-latitude sheep, probably because they have more resources available to them and thus can afford to be more particular. Analogously, northern individuals of *Edmontosaurus* may well have had a more generalized diet than their southern counterparts.

If the dinosaurs did not migrate, then presumably they would show adaptations supportive of year-round life in the high latitudes. *Troodon* provides the clearest example at the moment. This small, meat-eating dinosaur, known mainly from its teeth, is rare in more southern places, such as Alberta, Montana and Texas. In contrast, isolated teeth of this animal are very common in Alaska, which suggests that the population was large and widespread. What sets *Troodon*—at any latitude—apart from other predatory dinosaurs is its exceptionally large eyes. Among modern animals, proportionately large eyes tend to be an adaptation for living in low light conditions. *Troodon* may have been preadapted to the physical constraints of the high-latitude environment, which gave it a competitive advantage and set it on the path to become the most abundant predator of the northern ecosystem.

If *Troodon* was well adapted to the low light of Arctic winters, one might wonder how it could function during the long periods of daylight in warmer months. The forest might have provided refuge then. Anyone who has walked through even a modestly dense forest can appreciate how much lower the light level is in the woods than it is in an open field. In such an environment *Troodon's* large eyes would have continued to make it a fearsome predator.

We cannot confirm the size of the eyes of the other dinosaurs that lived in Alaska, because those parts of the skulls are only fragmentary or the bones are still being prepared for study. Although the dinosaurs described from southern Australia by Tom and Pat Rich are much older and very different, the Riches did note a pattern of increased orbital diameters for some dinosaurs.

Interestingly, *Troodon* in the Arctic were nearly twice the size of *Troodon* found in more southern locations. This difference contrasts sharply with the pattern discerned from measuring the bones of herbivorous dinosaurs of the North Slope, which fall well within the size range of those found in lower latitudes. It could be that *Troodon's* large eyes gave it a competitive advantage, eventually allowing it to become the top predator and to increase in size. Observers have reported a similar phenomenon in modern ecosystems: where wolves have been removed, coyotes have sometimes achieved larger body sizes.

Lone Survivors?

CLEARLY, MANY QUESTIONS remain to be answered about these extraordinary creatures. One of the most fascinating is whether they might have survived beyond the catas-



trophe that killed off the dinosaurs in other parts of the world at the end of the Cretaceous period.

Most paleontologists believe that a collision between the earth and a large meteorite drove the dinosaurs to extinction. The most likely location for the impact is the Chicxulub Crater in Mexico. To study the far-reaching effects of such an impact, ideally one would look to a place far removed from the site, a place such as Alaska. Unfortunately, we have not found any fossils of dinosaurs in Alaska at just the right time to have a direct bearing on the question of whether dinosaurs died out abruptly or gradually. Fossil pollen data, however, offer tantalizing evidence that sections of rocks on the North Slope and elsewhere in Alaska are the right age to shed light on the extinction if they prove to contain fossils of fauna in addition to pollen. The possibility adds even more impetus to our search for ancient bones. We have just scratched the surface.

MORE TO EXPLORE

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