

Dinosaur Footprints *In memory of Paul Foulkes (Broome Courthouse markets original pancake man and local naturalist)*

Dinosaur skeletons are rarely found in Australia but the 'terrible lizards' left other spectacular evidence of their existence.

An 80-kilometre "dinosaur track way" in the Kimberley region of Western Australia is a scientific treasure, unparalleled anywhere else in the world.

The thousands of fossilised footprints were left by at least a dozen species of dinosaurs which lived 115 to 120 million years ago. They represent the largest number of footprints, the greatest diversity of dinosaur types and the best footprint preservation ever found, says Italian dinosaur expert Dr Giuseppe Leonardi.

Dr Leonardi, from Naples, and Australian palaeontologists' Dr Tony Thulborn and Mr Tim Hamley of the University of Queensland, claim the footprints provide a unique opportunity to study the ecology and lifestyles of the long-gone animals.

Since the track way was first scientifically studied in 1991, the three researchers have mapped, photographed and analysed "assemblages" of footprints, many superimposed one over the other as different animals walked over the same ground.

This kind of information helps determine which animals lived in the same area, how and where they travelled, and the kinds of activities in which they engaged.

Already, the scientists know that the track way was a plant-eaters paradise. Footprints of herbivorous dinosaurs, like Apatosaurus, vastly outnumber those of three-toed meat-eaters such as the tyrannosaurs.

It is possible that predator footprints are comparatively scarce because, with so many tasty plant-eaters for prey, they did not need to roam widely for food. Consequently, the big animals left fewer telltale impressions behind.

The footprints range in size from micro-tracks a few centimetres long to mega-prints nearly a metre in length.

They reveal that the main groups of dinosaurs all roamed the region, which stretches north and south of Broome: theropods, sauropods, ankylosaurs, ornithopods and stegosaurs.

Although there were earlier reports of isolated footprints, the remarkable scope of the track way was first observed during a 1991 fossil hunt organised by Dr John Long of the Western Australian Museum in Perth. The 40-member team included Dr Long, Dr Thulborn, and palaeontologists from the museum, the University of Queensland, and La Trobe University in Melbourne.

During the three-week expedition, the group also discovered a trove of prehistoric shark teeth and jaws, and bits of backbone from ancient marine reptiles, along with the first evidence of stegosaurs on the Australian continent. That finding solved the puzzle about the apparent absence of the Stegosauridae in Australia.

Moreover, those fossils are the world's only known stegosaur footprints.

In a real blow to science, the stegosaur prints were stolen in 1996. Thieves apparently cut the 100 kilogram fossils from the rocks with power tools. While the fossilised footprint of a three-toed dinosaur was recovered last year by WA police in Broome, the stegosaur tracks have never been found.

Although it is undoubtedly the most spectacular in size and scope, the WA track way is not the only site of dinosaur footprints found Down Under.

In the 1960s, a Queensland grazing property manager stumbled upon the fossilised remains of a 100 million-year-old dinosaur stampede near what is now the Lark Quarry Environmental Park near Winton.

And since the discovery of the WA track way, Dr Thulborn has reported the discovery of 155 million year-old dinosaur footprints in two Queensland collieries. Those were made by three-toed predators and bipedal ornithopods, amongst them a little creature with placed its tiny front "arms" on the ground like a grazing kangaroo

Ankylosaurus (an-KILE-oh-SAW-rus)

Literally "fused" or "stiff lizard". A medium sized, herbivorous (An animal that feeds only on plants, and is specially adapted to be able to extract nutrition from tough foliage.) dinosaur of the Late Cretaceous period (The Early Cretaceous period lasted from 144 million years ago to 97 million years ago. The Late Cretaceous period lasted from 97 to 65 million years ago.)

It had a heavily plated back and a club tail. All its bones had fused together so thickly that there was very little room for a brain. It was up to 10 metres long and weighed up to 7 tonnes.

Evidence

Ankylosaurus was named by Barnum Brown in 1908 and is known from three fairly complete specimens from Alberta, Wyoming and Hell Creek formation in Montana. Ankylosaur track ways have also been found near Sucre in Bolivia, South America and Broome, Western Australia. Its fossil remains are restricted to rocks from the Cretaceous period.

Ankylosaurus was a "bird-hipped" dinosaur from the heavily armoured group known as the ankylosaurs. Much of its skeleton was fused together to produce a heavily plated back. Its head had robust triangular horns in each corner. Its skull was nearly 1 metre long, very broad but very thick leaving little room for a brain.

Ankylosaurus was one of the larger armoured dinosaurs. Its club-like tail, the most impressive part of its body, was made of large clumps of bony tissue fused to the tail vertebrae and encased in tough reptilian skin. Its muscular tail was flexible and able to swing the club powerfully from side to side. *Ankylosaurus* was not built to reach upwards and grazed on low-lying plants.

Name:	Ankylosaurus
Pronunciation:	an-KILE-oh-SAW-rus
Meaning:	Fused or stiff lizard
Animal Type:	Dinosaur (ankylosaur)
Dietary Type:	Herbivore
Size:	Up to 10 metres long
Weight:	Up to 7 tonnes



Sauropods

Brachiosaurus (BRAK-ee-oh-SAW-rus)

A family of enormous herbivores (An animal that feeds only on plants, and is specially adapted to be able to extract nutrition from tough foliage.) that co-existed in herds on the plains. Included in this group are Diplodocus, Brachiosaurus, Apatosaurus and Camarasaurus.

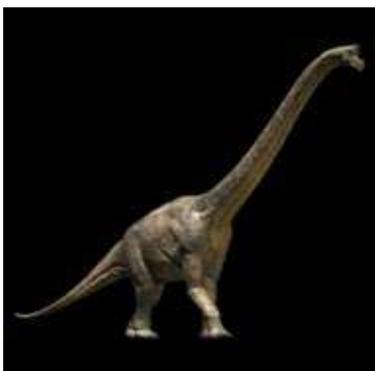
Evidence

Brachiosaurus ("arm reptile") from the Late Jurassic takes its name from the prodigious length of its forelegs when compared to its hind limbs. It was first described by Elmer Riggs on the basis of an incomplete skeleton discovered in 1900 at the Grand Junction, Colorado. A few years later several very fine skeletons were found at Tendaguru in Tanzania.

Brachiosaurus was one of the biggest land animals ever. Its weight has been estimated at about 80 tonnes, twenty times as heavy as a large elephant. Unlike other dinosaurs it had front legs longer than the hind ones, so that its back sloped upwards towards the head. In the Natural History Museum in Berlin there is a mounted skeleton of *Brachiosaurus*; the head is 13 metres above the ground, its upper arm bone is over 2 metres long, and it dwarfs the *Diplodocus* standing next to it.

With close cropping teeth for nipping food, it was adapted to eat the most elevated plant material such as conifer leaves and fruit. The upright stance and elevated neck meant that it could graze from trees at heights no other sauropod could reach. Its jaws were comparatively short and armed with chisel-like teeth for nipping leaves and fruit from tall conifer trees. It had unusually large nostrils on the top of its head.

Name:	Brachiosaurus
Pronunciation:	BRAK-ee-oh-SAW-rus
Meaning:	Arm lizard
Animal Type:	Dinosaur (sauropod)
Dietary Type:	Herbivore
Size:	25 metres long
Weight:	13 metres high
Weight:	70 tonnes



Diplodocus (dip-LOD-oh-kus)

Evidence

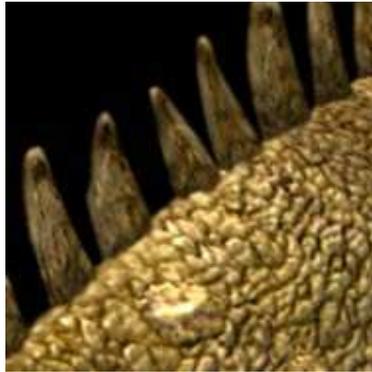
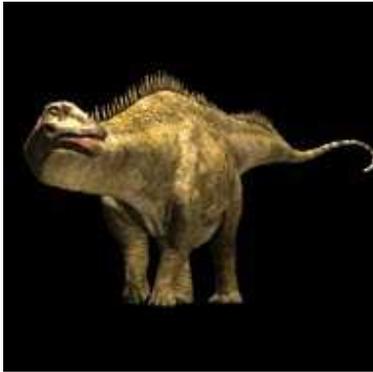
Five near complete skeletons of *Diplodocus* have been uncovered but the skull has always been missing. Skulls from partial skeletons have been used to complete the reconstruction. So far four distinct species have been identified from fossils in the Morrison Formation in Colorado and Wyoming.

Diplodocus was a "lizard-hipped" dinosaur. It was a sauropod, a group which were especially abundant in the Late Jurassic period. *Diplodocus* had simple peg-like teeth for stripping soft foliage like ferns but it could not chew. It swallowed stones which it held in its stomach. These gastroliths, as they are called, helped by grinding down the plant material.

Diplodocus was the longest of the land animals but not the heaviest. Much of its length was taken up with its strong whip-like tail. It had a brain the size of a fist. It had a concentration of nerves in the base of its spine. This helped it to cope with its enormous size, and control its hind legs and tail.

The largest *Diplodocus* is usually noted as being 15 tonnes and 27 metres long. A huge animal called *Seismosaurus* was found in New Mexico and many palaeontologists believe it is really an old *Diplodocus*. It weighed 30 tonnes and was 45 metres long.

Name:	Diplodocus
Pronunciation:	dip-LOD-oh-kus
Meaning:	Double beamed lizard Dinosaur (sauropod)
Animal Type:	Herbivore - likes ferns
Dietary Type:	Up to 45 metres long
Size:	Height at hips - up to 5 metres
Weight:	Up to 30 tonnes
Major Fossil Finds:	



Apatosaurus

A large four-footed herbivorous sauropod dinosaur up to 21m long and weighing more than 20 tonnes, which lived during the Upper Jurassic period. Apatosaurus used to be known by the name Brontosaurus.

Stegosaurus (STEG-oh-SAW-rus)

This huge, four-legged herbivore (An animal that feeds only on plants, and is specially adapted to be able to extract nutrition from tough foliage.) lived in the Late Jurassic period (The Jurassic Period lasted from about 205 million years ago to 144 million years ago). It is thought to have inhabited the plains and grazed in large herds alongside other herbivores like Diplodocus. It had a row of massive bony plates down its back, and a dangerous tail with four spikes to fend off attack from predators. It grew up to approximately 12 metres long and seven metres tall. It could weigh up to seven tonnes.

Stegosaur fossils are widely distributed from the United States to China showing how successful this dinosaur group was. There are many different types of stegosaur, of which *Stegosaurus* is the largest. The first *Stegosaurus* fossil was discovered in Colorado by M. P. Felch in 1877. Fossils from three different species of *Stegosaurus* have now been identified from the Morrison Formation in the Eastern United States. These finds have included complete skeletons and juvenile stegosaurus.

Stegosaurus was a herbivorous "bird-hipped" dinosaur. It had four sturdy legs and a line of plates running down its back. Its back legs were considerably longer and straighter than its front ones and it had a powerful beaked mouth for cropping vegetation.

For defence it used its formidable tail - a short and muscular weapon equipped with four 1 metre long spikes. It also had a series of bones under its neck that acted like chain mail to protect its throat.

The role of the plates is unclear with theories that they were used as armour, as a form of heat control or for display. Palaeontologists now think they were used for display - both for putting off attackers and for attracting a mate.

Name:	Stegosaurus
Pronunciation:	STEG-oh-SAW-rus
Meaning:	Covered lizard
Animal Type:	Dinosaur (stegosaur)
Dietary Type:	Herbivore - low level ferns
Size:	Up to 12 metres long
Weight:	Up to 7 tonnes



Theropod

A group of lizard hipped dinosaurs. All theropods were bipedal carnivores (An animal that eats other animals.) and ranged from the lightly built forms such as *Coelophysis* to the massive *Tyrannosaurus*.

Tyrannosaurus (tie-RAN-oh-SAW-rus)

This huge two legged carnivore (An animal that eats other animals.) lived in the Late Cretaceous period (The Early Cretaceous period lasted from 144 million years ago to 97 million years ago. The Late Cretaceous period lasted from 97 to 65 million years ago.). It roamed around the forests and marshes searching for prey. Its long, serrated teeth and enormous jaw made it a fearsome predator. It was 12.4 metres long, and weighed five to seven tonnes.

Evidence

The first reasonably complete *Tyrannosaurus* skeleton was discovered by palaeontologist Barnum Brown in Hell Creek, Montana in 1902. Until this find only fragments had been unearthed. In all, over 20 individuals have been found, although, only three have complete skulls. Remains have been discovered from Alberta to New Mexico, all from rocks of the late Cretaceous period.

Tyrannosaurus was the largest of the "lizard-hipped" carnivorous dinosaurs known as theropods. It was a massive two legged predator with a powerful tail, large head and tiny arms.

Tyrannosaurus's primary weapon was its mouth, with a 1.2 metre long jaw and a 1 metre gape. Its curved serrated teeth were longer than a human hand. With these it could puncture an animal's organs, before tearing the flesh off. The *Tyrannosaurus* could not chew, so had to swallow its food whole. It could probably gulp up to 70 kilograms in one go. One fossil shows the danger of this - a large carnivore had died swallowing, with two long bones stuck in its gullet.

Its tiny two-fingered arms seemed very small, but were believed to have been at least three times as strong as human arms. They were too short to reach its mouth, but were probably used as meat-hooks. There is clear evidence that tyrannosaurs fought one another from tooth-marks left in fossil remains.

Name:	Tyrannosaurus
Pronunciation:	tie-RAN-oh-SAW-rus
Meaning:	Tyrant Lizard
Animal Type:	Dinosaur (theropod)
Dietary Type:	Carnivore
Size:	Up to 14 metres long Up to 5 metres tall
Weight:	Up to 5 tonnes



Why are there so few Aussie dinosaurs?

In the dinosaur stakes, Australia was dealt a poor hand for a number of reasons. Firstly, when dinosaurs were roamed the earth, there were few places where the right kinds of rocks were being deposited. Dinosaurs tend to be preserved in sediments laid down by rivers and lakes. During the reign of the dinosaurs most of Australia was covered by a shallow sea.

Secondly, since the age of dinosaurs, there has not been much mountain-building in Australia. If land is lifted up and eroded back, it's possible to see into the rock beds and find the fossils inside. This has happened in a number of the world's famous dinosaur deposits elsewhere in the world but not here in Australia.

Lastly, compared to many other places in the world, Australia has very few palaeontologists looking for fossils and a very large area to cover. This is slowly changing and the recent increase in dinosaur fossil finds is a result of more palaeontologists getting out and digging around.

What do Aussie dinosaur fossils tell us about Australia in the age of dinosaurs?

During the age of dinosaurs Australia was much closer to the South Pole than it is now. This meant that Australia was much colder than it is today and that there were long periods of darkness each year. Dinosaurs such as *Leaellynasaura* are small with large eyes. It is unlikely that they could have migrated in and out of what is now southern Victoria so they must have been able to see in low light conditions and keep warm in the long, cold winters.

Australia was also connected to Antarctica and South America during the time of the dinosaurs. This allowed some movement of dinosaurs and other animals across continents that are now separated by vast oceans. Similarities between some Australian dinosaurs to others found on the other southern continents indicate a long history of movements back and forth between Australia and neighbouring continents.

What else lived with the dinosaurs in Australia?

Australia has a very good record of the animals that lived in the seas while dinosaurs roamed the land. Long-necked plesiosaurs such as *Woolungasaurus* were preyed upon by their short-necked relatives *Kronosaurus*. Ichthyosaurs torpedoed through the water like modern dolphins. Ammonites and huge platey relatives of oysters filled the waters and covered the sea floor.

On the land there was a range of turtles, crocodiles and other smaller reptiles as well as a few mammals related to modern platypus and echidna. The air was home to several types of flying reptiles but their fragile bones were rarely fossilised. Toward the end of the age of dinosaurs birds made their first appearance in Australia, poised to take over from the dinosaurs after the great Cretaceous Extinction.

The Broome connection.

In late June and early July 1997, Tony Thulborn, Giuseppe Leonardi (Naples) and Tim Hamley (Dr Thulborn's part-time student-assistant) made a trip to Broome, Western Australia, where they discovered thousands of dinosaur footprints in the Lower Cretaceous Broome sandstone along the coastline.

The stretch of coastline had been swept clean by the last cyclone (called a hurricane in the Northern Hemisphere) to reveal an Early Cretaceous land-surface virtually intact, with the original topography, channels and hillocks, tree-stumps and root systems in their position of growth. Footprints included sauropods, ornithopods, theropods and some mystery items including supposed stegosaur tracks. Photographs and latex peels were made where possible, although only on a small scale.

A brief summary of the previously known Broome tracks, with emphasis on sauropods, was published in the journal *Gaia*, volume 10, 1994. Some scientists thought that aspects of the account were exaggerated, such as unusually big sauropod prints (up to 1.5 m long), the exceptional diversity (at least 10 different types of track-makers), and the co-occurrence of sauropod and ornithopod tracks (sometimes thought to be ecologically separated).

On returning to Broome they told the late **Paul Foulkes (a naturalist and Broome local)** of the sites, who set off to see for himself. He returned, reporting that he'd found even more newly-uncovered tracks.

At a conference in Perth, the following week, the discovery was discussed within earshot of a stray reporter. As a result newspaper reports had the find as a single unbroken dinosaur "highway" 80km long. Although the footprint sites (plural) do extend over 80 to 100 km of coast, it is NOT a single exposure or one continuous track way surface. It is a series of sites, many of them rather small, with (sometimes vast) stretches of beach between them. The sites don't all seem to be at the same stratigraphic level and they appear to represent a variety of environments (forest, swamp, lagoon, fluvial/deltaic) each with its own distinctive suite of dinosaur track types. The newly-exposed sites seem to represent fairly well-vegetated forest or swamp environments. Sauropod tracks seem to dominate the lagoonal settings.

Resources: - Information about dinky-di dinosaurs compiled by Quantum's Leigh Dayton and Dr. Paul Willis