= Acrocanthosaurus =

Acrocanthosaurus (/ ?ækro??kæn???s??r?s / ak @-@ ro @-@ KAN @-@ th? @-@ SAWR @-@ ?s ; meaning " high @-@ spined lizard ") is a genus of theropod dinosaur that existed in what is now North America during the Aptian and early Albian stages of the Early Cretaceous . Like most dinosaur genera , Acrocanthosaurus contains only a single species , A. atokensis . Its fossil remains are found mainly in the U.S. states of Oklahoma , Texas , and Wyoming , although teeth attributed to Acrocanthosaurus have been found as far east as Maryland .

Acrocanthosaurus was a bipedal predator . As the name suggests , it is best known for the high neural spines on many of its vertebrae , which most likely supported a ridge of muscle over the animal 's neck , back and hips . Acrocanthosaurus was one of the largest theropods , approaching 11 @.@ 5 m (38 ft) in length , and weighing up to 6 @.@ 2 tonnes (6 @.@ 8 short tons) . Large theropod footprints discovered in Texas may have been made by Acrocanthosaurus , although there is no direct association with skeletal remains .

Recent discoveries have elucidated many details of its anatomy , allowing for specialized studies focusing on its brain structure and forelimb function . Acrocanthosaurus was the largest theropod in its ecosystem and likely an apex predator which preyed on sauropods , ornithopods , and ankylosaurs .

= = Description = =

Acrocanthosaurus was among the largest theropods known to exist . The largest known specimen (NCSM 14345) is estimated to have measured 11 @.@ 5 m (38 ft) from snout to tail tip and weighed 5 @.@ 7 t (6 @.@ 3 short tons) to 6 @.@ 2 t (6 @.@ 8 short tons) , with an upper maximum weight of 7 @.@ 25 t (7 @.@ 99 short tons) within the realm of possibility for this specimen . Its skull alone was nearly 1 @.@ 3 m (4 @.@ 3 ft) in length .

The skull of Acrocanthosaurus , like most other allosauroids , was long , low and narrow . The weight @-@ reducing opening in front of the eye socket (antorbital fenestra) was quite large , more than a quarter of the length of the skull and two @-@ thirds of its height . The outside surface of the maxilla (upper jaw bone) and the upper surface of the nasal bone on the roof of the snout were not nearly as rough @-@ textured as those of Giganotosaurus or Carcharodontosaurus . Long , low ridges arose from the nasal bones , running along each side of the snout from the nostril back to the eye , where they continued onto the lacrimal bones . This is a characteristic feature of all allosauroids . Unlike Allosaurus , there was no prominent crest on the lacrimal bone in front of the eye . The lacrimal and postorbital bones met to form a thick brow over the eye , as seen in carcharodontosaurids and the unrelated abelisaurids . Nineteen curved , serrated teeth lined each side of the upper jaw , but a tooth count for the lower jaw has not been published . Acrocanthosaurus teeth were wider than those of Carcharodontosaurus and did not have the wrinkled texture that characterized the carcharodontosaurids . The dentary (tooth @-@ bearing lower jaw bone) was squared off at the front edge , as in Giganotosaurus , and shallow , while the rest of the jaw behind it became very deep . Acrocanthosaurus and Giganotosaurus shared a thick horizontal ridge on the outside surface of the surangular bone of the lower jaw , underneath the articulation with the skull .

The most notable feature of Acrocanthosaurus was its row of tall neural spines , located on the vertebrae of the neck , back , hips and upper tail , which could be more than 2 @.@ 5 times the height of the vertebrae from which they extended . Other dinosaurs also had high spines on the back , sometimes much higher than those of Acrocanthosaurus . For instance , the unrelated Spinosaurus had spines nearly 2 meters (6 @.@ 5 ft) tall , about 11 times taller than the bodies of its vertebrae . The lower spines of Acrocanthosaurus had attachments for powerful muscles like those of modern bison , probably forming a tall , thick ridge down its back . The function of the spines remains unknown , although they may have been involved in communication , fat storage , or temperature control . All of its cervical (neck) and dorsal (back) vertebrae had prominent depressions (pleurocoels) on the sides , while the caudal (tail) vertebrae bore smaller ones . This

is more similar to carcharodontosaurids than to Allosaurus .

Aside from its vertebrae , Acrocanthosaurus had a typical allosauroid skeleton . Acrocanthosaurus was bipedal , with a long , heavy tail counterbalancing the head and body , maintaining its center of gravity over its hips . Its forelimbs were relatively shorter and more robust than those of Allosaurus but were otherwise similar : each hand bore three clawed digits . Unlike many smaller fast @-@ running dinosaurs , its femur was longer than its tibia and metatarsals , suggesting that Acrocanthosaurus was not a fast runner . Unsurprisingly , the hind leg bones of Acrocanthosaurus were proportionally more robust than its smaller relative Allosaurus . Its feet had four digits each , although as is typical for theropods , the first was much smaller than the rest and did not make contact with the ground .

= = Classification and systematics = =

Acrocanthosaurus is classified in the superfamily Allosauroidea within the infraorder Tetanurae . This superfamily is characterized by paired ridges on the nasal and lacrimal bones on top of the snout and tall neural spines on the neck vertebrae , among other features . It was originally placed in the family Allosauridae with Allosaurus , an arrangement also supported by studies as late as 2000 . Most studies have found it to be a member of the related family Carcharodontosauridae .

At the time of its discovery , Acrocanthosaurus and most other large theropods were known from only fragmentary remains , leading to highly variable classifications for this genus . J. Willis Stovall and Wann Langston Jr. first assigned it to the " Antrodemidae " , the equivalent of Allosauridae , but it was transferred to the taxonomic wastebasket Megalosauridae by Alfred Sherwood Romer in 1956 . To other authors , the long spines on its vertebrae suggested a relationship with Spinosaurus . This interpretation of Acrocanthosaurus as a spinosaurid persisted into the 1980s , and was repeated in the semi @-@ technical dinosaur books of the time .

Tall spined vertebrae from the Early Cretaceous of England were once considered to be very similar to those of Acrocanthosaurus , and in 1988 Gregory S. Paul named them as a second species of the genus , A. altispinax . These bones were originally assigned to Altispinax , an English theropod otherwise known only from teeth , and this assignment led to at least one author proposing that Altispinax itself was a synonym of Acrocanthosaurus . These vertebrae were later assigned to the new genus Becklespinax , separate from both Acrocanthosaurus and Altispinax .

Most cladistic analyses including Acrocanthosaurus have found it to be a carcharodontosaurid , usually in a basal position relative to the African Carcharodontosaurus and Giganotosaurus from South America . It has often been considered the sister taxon to the equally basal Eocarcharia , also from Africa . Neovenator , discovered in England , is often considered an even more basal carcharodontosaurid , or as a basal member of a sister group called Neovenatoridae . This suggests that the family originated in Europe and then dispersed into the southern continents (at the time united as the supercontinent Gondwana) . If Acrocanthosaurus was a carcharodontosaurid , then dispersal would also have occurred into North America . All known carcharodontosaurids lived during the early @-@ to @-@ middle Cretaceous Period .

The following cladogram after Novas et al . , 2013 , shows the placement of Acrocanthosaurus within Carcharodontosauridae .

= = Discovery and naming = =

Acrocanthosaurus is named for its tall neural spines , from the Greek ???? / akra (' high ') , ?????? / akantha (' thorn ' or ' spine ') and ?????? / sauros (' lizard ') . There is one named species (A. atokensis) , which is named after Atoka County in Oklahoma , where the original specimens were found . The name was coined in 1950 by American paleontologists J. Willis Stovall and Wann Langston Jr . Langston had proposed the name " Acracanthus atokaensis " for the genus and species in his unpublished 1947 master 's thesis , but the name was changed to Acrocanthosaurus atokensis for formal publication .

The holotype and paratype (OMNH 10146 and OMNH 10147) , discovered in the early 1940s and

described at the same time in 1950 , consist of two partial skeletons and a piece of skull material from the Antlers Formation in Oklahoma . Two much more complete specimens were described in the 1990s . The first (SMU 74646) is a partial skeleton , missing most of the skull , recovered from the Twin Mountains Formation of Texas and currently part of the Fort Worth Museum of Science and History collection . An even more complete skeleton (NCSM 14345 , nicknamed " Fran ") was recovered from the Antlers Formation of Oklahoma by Cephis Hall and Sid Love , prepared by the Black Hills Institute in South Dakota , and is now housed at the North Carolina Museum of Natural Sciences in Raleigh . This specimen is the largest and includes the only known complete skull and forelimb . Skeletal elements of OMNH 10147 are almost the same size as comparable bones in NCSM 14345 , indicating an animal of roughly the same size , while the holotype and SMU 74646 are significantly smaller .

The presence of Acrocanthosaurus in the Cloverly Formation was established in 2012 with the description of another partial skeleton , UM 20796 . This specimen , consisting of parts of two vertebrae , partial pubic bones , a femur , a partial fibula , and fragments , represents a juvenile animal . It came from a bonebed in the Bighorn Basin of north @-@ central Wyoming , and was found near the shoulder blade of a Sauroposeidon . An assortment of other fragmentary theropod remains from the formation may also belong to Acrocanthosaurus , which may be the only large theropod in the Cloverly Formation .

Acrocanthosaurus may be known from less complete remains outside of Oklahoma , Texas , and Wyoming . A tooth from southern Arizona has been referred to the genus , and matching tooth marks have been found in sauropod bones from the same area . Several teeth from the Arundel Formation of Maryland have been described as almost identical to those of Acrocanthosaurus and may represent an eastern representative of the genus . Many other teeth and bones from various geologic formations throughout the western United States have also been referred to Acrocanthosaurus , but most of these have been misidentified ; there is , however , some disagreement with this assessment regarding fossils from the Cloverly Formation .

= = Paleobiology = =

= = = Growth and longevity = = =

From the bone features of the holotype OMNH 10146 and NCSM 14345 , it is estimated that Acrocanthosaurus requires at least 12 years to fully grow . This number may be much higher because in the process of bones remodeling and the growth of the medullary cavity , some Harris lines were lost . If accounting for these lines , Acrocanthosaurus needs 18 ? 24 years to be mature .

= = = Forelimb function = = =

Like those of most other non @-@ avian theropods , Acrocanthosaurus forelimbs did not make contact with the ground and were not used for locomotion ; instead they served a predatory function . The discovery of a complete forelimb (NCSM 14345) allowed the first analysis of the function and range of motion of the forelimb in Acrocanthosaurus . The study examined the bone surfaces which would have articulated with other bones to determine how far the joints could move without dislocating . In many of the joints , the bones did not fit together exactly , indicating the presence of a considerable amount of cartilage in the joints , as is seen in many living archosaurs . Among other findings , the study suggested that , in a resting position , the forelimbs would have hung from the shoulders with the humerus angled backwards slightly , the elbow bent , and the claws facing medially (inwards) . The shoulder of Acrocanthosaurus was limited in its range of motion compared to that of humans . The arm could not swing in a complete circle , but could retract (swing backwards) 109 ° from the vertical , so that the humerus could actually be angled slightly upwards . Protraction (swinging forward) was limited to only 24 ° past the vertical . The arm was unable to reach a vertical position when adducting (swinging downwards) , but could abduct (swing upwards

) to 9 ° above horizontal . Movement at the elbow was also limited compared to humans , with a total range of motion of only 57 ° . The arm could not completely extend (straighten) , nor could it flex (bend) very far , with the humerus unable even to form a right angle with the forearm . The radius and ulna (forearm bones) locked together so that there was no possibility of pronation or supination (twisting) as in human forearms .

None of the carpals (wrist bones) fit together precisely , suggesting the presence of a large amount of cartilage in the wrist , which would have stiffened it . All of the digits were able to hyperextend (bend backwards) until they nearly touched the wrist . When flexed , the middle digit would converge towards the first digit , while the third digit would twist inwards . The first digit of the hand bore the largest claw , which was permanently flexed so that it curved back towards the underside of the hand . Likewise , the middle claw may have been permanently flexed , while the third claw , also the smallest , was able to both flex and extend .

After determining the ranges of motion in the joints of the forelimb , the study went on to hypothesize about the predatory habits of Acrocanthosaurus . The forelimbs could not swing forward very far , unable even to scratch the animal 's own neck . Therefore , they were not likely to have been used in the initial capture of prey and Acrocanthosaurus probably led with its mouth when hunting . On the other hand , the forelimbs were able to retract towards the body very strongly . Once prey had been seized in the jaws , the heavily muscled forelimbs may have retracted , holding the prey tightly against the body and preventing escape . As the prey animal attempted to pull away , it would only have been further impaled on the permanently flexed claws of the first two digits . The extreme hyperextensibility of the digits may have been an adaptation allowing Acrocanthosaurus to hold struggling prey without fear of dislocation . Once the prey was trapped against the body , Acrocanthosaurus may have dispatched it with its jaws . Another possibility is that Acrocanthosaurus held its prey in its jaws , while repeatedly retracting its forelimbs , tearing large gashes with its claws .

= = = Brain and inner ear structure = = =

In 2005 , scientists reconstructed an endocast (replica) of an Acrocanthosaurus cranial cavity using computed tomography (CT scanning) to analyze the spaces within the holotype braincase (OMNH 10146) . In life , much of this space would have been filled with the meninges and cerebrospinal fluid , in addition to the brain itself . However , the general features of the brain and cranial nerves could be determined from the endocast and compared to other theropods for which endocasts have been created . While the brain is similar to many theropods , it is most similar to that of allosauroids . It most resembles the brains of Carcharodontosaurus and Giganotosaurus rather than those of Allosaurus or Sinraptor , providing support for the hypothesis that Acrocanthosaurus was a carcharodontosaurid .

The brain was slightly sigmoidal (S @-@ shaped) , without much expansion of the cerebral hemispheres , more like a crocodile than a bird . This is in keeping with the overall conservatism of non @-@ coelurosaurian theropod brains . Acrocanthosaurus had large and bulbous olfactory bulbs , indicating a good sense of smell . Reconstructing the semicircular canals of the ear , which control balance , shows that the head was held at a 25 ° angle below horizontal . This was determined by orienting the endocast so that the lateral semicircular canal was parallel to the ground , as it usually is when an animal is in an alert posture .

= = = Possible footprints = = =

The Glen Rose Formation of central Texas preserves many dinosaur footprints , including large , three @-@ toed theropod prints . The most famous of these trackways was discovered along the Paluxy River in Dinosaur Valley State Park , a section of which is now on exhibit in the American Museum of Natural History in New York City , although several other sites around the state have been described in the literature . It is impossible to say what animal made the prints , since no fossil bones have been associated with the trackways . However , scientists have long considered it likely

that the footprints belong to Acrocanthosaurus . A 2001 study compared the Glen Rose footprints to the feet of various large theropods but could not confidently assign them to any particular genus . However , the study noted that the tracks were within the ranges of size and shape expected for Acrocanthosaurus . Because the Glen Rose Formation is close to the Antlers and Twin Mountains Formations in both geographical location and geological age , and the only large theropod known from those formations is Acrocanthosaurus , the study concluded that Acrocanthosaurus was most likely to have made the tracks .

The famous Glen Rose trackway on display in New York City includes theropod footprints belonging to several individuals which moved in the same direction as up to twelve sauropod dinosaurs . The theropod prints are sometimes found on top of the sauropod footprints , indicating that they were formed later . This has been put forth as evidence that a small pack of Acrocanthosaurus was stalking a herd of sauropods . While interesting and plausible , this hypothesis is difficult to prove and other explanations exist . For example , several solitary theropods may have moved through in the same direction at different times after the sauropods had passed , creating the appearance of a pack stalking its prey . The same can be said for the purported " herd " of sauropods , who also may or may not have been moving as a group . At a point where it crosses the path of one of the sauropods , one of the theropod trackways is missing a footprint , which has been cited as evidence of an attack . However , other scientists doubt the validity of this interpretation because the sauropod did not change gait , as would be expected if a large predator were hanging onto its side .

= = = Pathology = = =

The skull of the Acrocanthosaurus atokensis holotype shows light exostotic material on the squamosal . The neural spine of the eleventh vertebra was fractured and healed while the neural spine of its third tail vertebra had an unusual hook @-@ like structure .

= = Paleoecology = =

Definite Acrocanthosaurus fossils have been found in the Twin Mountains Formation of northern Texas , the Antlers Formation of southern Oklahoma , and the Cloverly Formation of north @-@ central Wyoming and possibly even the Arundel Formation in Maryland and in Florida . These geological formations have not been dated radiometrically , but scientists have used biostratigraphy to estimate their age . Based on changes in ammonite taxa , the boundary between the Aptian and Albian stages of the Early Cretaceous has been located within the Glen Rose Formation of Texas , which may contain Acrocanthosaurus footprints and lies just above the Twin Mountains Formation . This indicates that the Twin Mountains Formation lies entirely within the Aptian stage , which lasted from 125 to 112 million years ago . The Antlers Formation contains fossils of Deinonychus and Tenontosaurus , two dinosaur genera also found in the Cloverly Formation , which has been radiometrically dated to the Aptian and Albian stages , suggesting a similar age for the Antlers . Therefore , Acrocanthosaurus most likely existed between 125 and 100 million years ago .

During this time , the area preserved in the Twin Mountains and Antlers formations was a large floodplain that drained into a shallow inland sea . A few million years later , this sea would expand to the north , becoming the Western Interior Seaway and dividing North America in two for nearly the entire Late Cretaceous . The Glen Rose Formation represents a coastal environment , with possible Acrocanthosaurus tracks preserved in mudflats along the ancient shoreline . As Acrocanthosaurus was a large predator , it is expected that it had an extensive home range and lived in many different environments in the area . Potential prey animals include sauropods like Astrodon or possibly even the enormous Sauroposeidon , as well as large ornithopods like Tenontosaurus . The smaller theropod Deinonychus also prowled the area but at 3 m (10 ft) in length , most likely provided only minimal competition for Acrocanthosaurus .