

= Deinosuchus =

Deinosuchus (/ ˈdaɪnəʊsjuːkʊs / DY @-@ n? @-@ SEW @-@ k?s) is an extinct genus related to the alligator that lived 80 to 73 million years ago (Ma) , during the late Cretaceous period . The name translates as " terrible crocodile " and is derived from the Greek deinós (??????) , " terrible " , and soukhos (??????) , " crocodile " . The first remains were discovered in North Carolina (United States) in the 1850s ; the genus was named and described in 1909 . Additional fragments were discovered in the 1940s and were later incorporated into an influential , though inaccurate , skull reconstruction at the American Museum of Natural History . Knowledge of Deinosuchus remains incomplete , but better cranial material found in recent years has expanded scientific understanding of this massive predator .

Although Deinosuchus was far larger than any modern crocodile or alligator , with the largest adults measuring 10 @. @ 6 m (35 ft) in total length , its overall appearance was fairly similar to its smaller relatives . It had large , robust teeth built for crushing , and its back was covered with thick hemispherical osteoderms . One study indicated Deinosuchus may have lived for up to 50 years , growing at a rate similar to that of modern crocodilians , but maintaining this growth over a much longer time .

Deinosuchus fossils have been found in 10 US states , including Texas , Montana , and many along the East Coast . Fossils have also been found in northern Mexico . It lived on both sides of the Western Interior Seaway , and was an opportunistic apex predator in the coastal regions of eastern North America . Deinosuchus reached its largest size in its western habitat , but the eastern populations were far more abundant . Opinion remains divided as to whether these two populations represent separate species . Deinosuchus was probably capable of killing and eating large dinosaurs . It may have also fed upon sea turtles , fish , and other aquatic and terrestrial prey .

= = Description = =

= = = Morphology = = =

Despite its large size , the overall appearance of Deinosuchus was not considerably different from that of modern crocodilians . Deinosuchus had an alligator @-@ like , broad snout , with a slightly bulbous tip . Each premaxilla contained four teeth , with the pair nearest to the tip of the snout being significantly smaller than the other two . Each maxilla (the main tooth @-@ bearing bone in the upper jaw) contained 21 or 22 teeth . The tooth count for each dentary (tooth @-@ bearing bone in the lower jaw) was at least 22 . All the teeth were very thick and robust ; those close to the rear of the jaws were short , rounded , and blunt . They appear to have been adapted for crushing , rather than piercing . When the mouth was closed , only the fourth tooth of the lower jaw would have been visible .

Modern saltwater crocodiles (*Crocodylus porosus*) have the strongest recorded bite of any living animal , with a maximum force of 16 @, @ 414 N (3 @, @ 690 lbf) . The bite force of Deinosuchus has been estimated to be 18 @, @ 000 N (4 @, @ 000 lbf) to 100 @, @ 000 N (22 @, @ 000 lbf) . It has been argued that even the largest and strongest theropod dinosaurs , such as *Tyrannosaurus* , probably had bite forces inferior to that of Deinosuchus .

Deinosuchus had a secondary bony palate , which would have permitted it to breathe through its nostrils while the rest of the head remained submerged underwater . The vertebrae were articulated in a procoelous manner , meaning they had a concave hollow on the front end and a convex bulge on the rear ; these would have fit together to produce a ball and socket joint . The secondary palate and procoelous vertebrae are advanced features also found in modern eusuchian crocodilians .

The osteoderms (scutes) covering the back of Deinosuchus were unusually large , heavy , and deeply pitted ; some were of a roughly hemispherical shape . Deep pits and grooves on these osteoderms served as attachment points for connective tissue . Together , the osteoderms and connective tissue would have served as load @-@ bearing reinforcement to support the massive

body of Deinosuchus out of water . These deeply pitted osteoderms have been used to suggest that , despite its bulk , Deinosuchus could probably have walked on land much like modern @-@ day crocodiles .

== Size ==

The large size of Deinosuchus has generally been recognized despite the fragmentary nature of the fossils assigned to it . However , estimates of how large it really was have varied considerably over the years . The original estimate from 1954 for the type specimen of the then @-@ named " Phobosuchus riograndensis " were based on a skull of 1 @. @ 5 m (4 @. @ 9 ft) and a lower jaw of 1 @. @ 8 m (5 @. @ 9 ft) long , reconstructed with similar proportions to the Cuban crocodile giving a total estimated length of 15 m (49 ft) . However , this reconstruction is currently considered to be inaccurate . Using more complete remains , it was estimated in 1999 that the size attained by specimens of Deinosuchus varied from 8 to 10 m (26 to 33 ft) with weights from 2 @. @ 5 to 5 t (2 @. @ 8 to 5 @. @ 5 short tons) . This was later corroborated when it was noted that most known specimens of D. rugosus usually had skulls of about 1 m (3 @. @ 3 ft) with estimated total lengths of 8 m (26 ft) and weights of 2 @. @ 3 t (2 @. @ 5 short tons) . A reasonably well @-@ preserved skull specimen discovered in Texas indicated the animal 's head measured about 1 @. @ 31 m (4 @. @ 3 ft) , and its body length was estimated at 9 @. @ 8 m (32 ft) . However , the largest fragmentary remains of D. riograndensis were 1 @. @ 5 times the size of those of the average D. rugosus and it was determined that the largest individuals of this species may have been up to 12 m (39 ft) in length and perhaps weighed as much as 8 @. @ 5 t (9 @. @ 4 short tons) .

A particularly large mandibular fragment from a D. riograndensis specimen was estimated to have come from an individual with a skull length of about 147 @. @ 5 cm (4 @. @ 84 ft) . This length was used in conjunction with a regression equation relating skull length to total length in the American alligator to estimate a total length of 10 @. @ 6 metres (35 ft) for this particularly specimen . This is only slightly lower than previous estimates for the species . Deinosuchus has often been described as the largest crocodyliform of all time . However other crocodyliformes such as Purussaurus , Rhamphosuchus , and Sarcosuchus may have equaled or exceeded it in size .

== Paleobiology ==

== Habitat ==

Deinosuchus was present on both sides of the Western Interior Seaway . Specimens have been found in 10 U.S. states : Utah , Montana , Wyoming , New Mexico , New Jersey , Georgia , Alabama , Mississippi , Texas , and North Carolina . A Deinosuchus osteoderm from the San Carlos Formation was also reported in 2006 , so the giant crocodilian 's range may have included parts of northern Mexico . Deinosuchus fossils are most abundant in the Gulf Coastal Plain region of Georgia , near the Alabama border . All known specimens of Deinosuchus were found in rocks dated to the Campanian stage of the Late Cretaceous period . The oldest examples of this genus lived approximately 80 Ma , and the youngest lived around 73 Ma .

The distribution of Deinosuchus specimens indicates these giant crocodilians may have preferred estuarine environments . In the Aguja Formation of Texas , where some of the largest specimens of Deinosuchus have been found , these massive predators probably inhabited brackish @-@ water bays . Although some specimens have also been found in marine deposits , it is not clear whether Deinosuchus ventured out into the ocean (like modern @-@ day saltwater crocodiles) ; these remains might have been displaced after the animals died . Deinosuchus has been described as a " conspicuous " component of a purportedly distinct biome occupying the southern half of Late Cretaceous North America .

== Diet ==

In 1954 , Edwin H. Colbert and Roland T. Bird speculated that *Deinosuchus* " may very well have hunted and devoured some of the dinosaurs with which it was contemporaneous " . Colbert restated this hypothesis more confidently in 1961 : " Certainly this crocodile must have been a predator of dinosaurs ; otherwise why would it have been so overwhelmingly gigantic ? It hunted in the water where the giant theropods could not go . " David R. Schwimmer proposed in 2002 that several hadrosaurid tail vertebrae found near Big Bend National Park show evidence of *Deinosuchus* tooth marks , strengthening the hypothesis that *Deinosuchus* fed on dinosaurs in at least some instances . In 2003 , Christopher A. Brochu agreed that *Deinosuchus* " probably dined on ornithopods from time to time . " *Deinosuchus* is generally thought to have employed hunting tactics similar to those of modern crocodilians , ambushing dinosaurs and other terrestrial animals at the water 's edge and then submerging them until they drowned . A 2014 study suggested that it would have been able to perform a " death roll " , like modern crocodiles .

Schwimmer and G. Dent Williams proposed in 1996 that *Deinosuchus* may have preyed on marine turtles . *Deinosuchus* would probably have used the robust , flat teeth near the back of its jaws to crush the turtle shells . The " side @-@ necked " sea turtle *Bothremys* was especially common in the eastern habitat of *Deinosuchus* , and several of its shells have been found with bite marks that were most likely inflicted by the giant crocodilian .

Schwimmer concluded in 2002 that the feeding patterns of *Deinosuchus* most likely varied by geographic location ; the smaller *Deinosuchus* specimens of eastern North America would have been opportunistic feeders in an ecological niche similar to that of the modern American alligator . They would have consumed marine turtles , large fish , and smaller dinosaurs . The bigger , but less common , *Deinosuchus* that lived in Texas and Montana might have been more specialized hunters , capturing and eating large dinosaurs . Schwimmer noted no theropod dinosaurs in *Deinosuchus* 's eastern range approached its size , indicating the massive crocodilian could have been the region 's apex predator .

In 2016 , Mark Witton took a rigorous look at *Deinosuchus* ' diet . His results show that , although *Deinosuchus* did eat dinosaurs , its diet was mostly made up of sea turtles .

= = = Growth rates = = =

A 1999 study by Gregory M. Erickson and Christopher A. Brochu suggested the growth rate of *Deinosuchus* was comparable to that of modern crocodilians , but was maintained over a far longer time . Their estimates , based on growth rings in the dorsal osteoderms of various specimens , indicated each *Deinosuchus* might have taken over 35 years to reach full adult size , and the oldest individuals may have lived for more than 50 years . This was a completely different growth strategy than that of large dinosaurs , which reached adult size much more quickly and had shorter lifespans . According to Erickson , a full @-@ grown *Deinosuchus* " must have seen several generations of dinosaurs come and go " .

Schwimmer noted in 2002 that Erickson and Brochu 's assumptions about growth rates are only valid if the osteodermal rings reflect annual periods , as they do in modern crocodilians . According to Schwimmer , the growth ring patterns observed could have been affected by a variety of factors , including " migrations of their prey , wet @-@ dry seasonal climate variations , or oceanic circulation and nutrient cycles " . If the ring cycle were biannual rather than annual , this might indicate *Deinosuchus* grew faster than modern crocodilians , and had a similar maximum lifespan .

= = Discovery and naming = =

In 1858 , geologist Ebenezer Emmons described two large fossil teeth found in Bladen County , North Carolina . Emmons assigned these teeth to *Polyptychodon* , which he then believed to be " a genus of crocodilian reptiles " . Later discoveries showed that *Polyptychodon* was actually a pliosaur , a type of marine reptile . The teeth described by Emmons were thick , slightly curved , and covered with vertically grooved enamel ; he assigned them a new species name , *P. rugosus* . Although not

initially recognized as such , these teeth were probably the first *Deinosuchus* remains to be scientifically described . Another large tooth that likely came from *Deinosuchus* , discovered in neighboring Sampson County , was named *Polydectes biturgidus* by Edward Drinker Cope in 1869 .

In 1903 , at Willow Creek , Montana , several fossil osteoderms were discovered " lying upon the surface of the soil " by John Bell Hatcher and T.W. Stanton . These osteoderms were initially attributed to the ankylosaurid dinosaur *Euoplocephalus* . Excavation at the site , carried out by W.H. Utterback , yielded further fossils , including additional osteoderms , as well as vertebrae , ribs , and a pubis . When these specimens were examined , it became clear that they belonged to a large crocodilian and not a dinosaur ; upon learning this , Hatcher " immediately lost interest " in the material . After Hatcher died in 1904 , his colleague W.J. Holland studied and described the fossils . Holland assigned these specimens to a new genus and species , *Deinosuchus hatcheri* , in 1909 . *Deinosuchus* comes from the Greek ?????? / *deinos* , meaning " terrible " , and ?????? / *suchos* , meaning " crocodile " .

A 1940 expedition by the American Museum of Natural History yielded more fossils of giant crocodilians , this time from Big Bend National Park in Texas . These specimens were described by Edwin H. Colbert and Roland T. Bird in 1954 , under the name *Phobosuchus riograndensis* . Donald Baird and Jack Horner later assigned the Big Bend remains to *Deinosuchus* , which has been accepted by most modern authorities . The genus name *Phobosuchus* , which was initially created by Baron Franz Nopcsa in 1924 , has since been discarded because it contained a variety of different crocodilian species that turned out to not be closely related to each other .

The American Museum of Natural History incorporated the skull and jaw fragments into a plaster restoration , modeled after the present @-@ day Cuban crocodile . Colbert and Bird stated this was a " conservative " reconstruction , since an even greater length could have been obtained if a long @-@ skulled modern species , such as the saltwater crocodile had been used as the template . Because it was not then known that *Deinosuchus* had a broad snout , Colbert and Bird miscalculated the proportions of the skull , and the reconstruction greatly exaggerated its overall width and length . Despite its inaccuracies , the reconstructed skull became the best @-@ known specimen of *Deinosuchus* , and brought public attention to this giant crocodilian for the first time .

Numerous additional specimens of *Deinosuchus* were discovered over the next several decades . Most were quite fragmentary , but they expanded knowledge of the giant predator 's geographic range . As noted by Chris Brochu , the osteoderms are distinctive enough that even " bone granola " can adequately confirm the presence of *Deinosuchus* . Better cranial material was also found ; by 2002 , David R. Schwimmer was able to create a composite computer reconstruction of 90 % of the skull .

= = Classification and species = =

Since the discovery of the earliest fragmentary remains that will come to be known as *Deinosuchus* , it was found that it was a relative of crocodiles , going as far as placing it in the same family (*crocodylidae*) in 1954 , this assignment was mostly supported by dental features but was overturned in 1999 when the finding of new specimens from Texas and Georgia helped place *Deinosuchus* in a phylogenetic analysis , finding it in a basal position within the clade *Alligatoroidea* along with *Leidyosuchus* . This classification was bolstered in 2005 by the discovery of a well @-@ preserved *Deinosuchus* brain case from the Blufftown Formation of Alabama , which shows some features reminiscent of those in the modern American alligator , *Deinosuchus* however , was not a direct ancestor of modern alligators .

The species pertaining to *Deinosuchus* since the resurrection of the generic name in 1979 have been traditionally recognized as *D. rugosus* from the eastern side of the Western Interior Seaway and the larger *D. riograndensis* from the western side , characterized by differences of the shape of their osteoderms and teeth , this view was not always favored by all researchers and in 2002 it was proposed that there was only one species , *Deinosuchus rugosus* , with the differences found between the two species explained as the result of the larger size of the western morph . This

proposal faced support and criticism and was dropped in 2010 when new fossils of specimens from both sides of the interior seaway showed that the differences between the two morphs were not just size related , teeth from large eastern specimens retained the common characteristics of other specimens of the region and osteoderms from small specimens of the western morph were no different from those of large ones , supporting the specific separation of the two morphs , now formalized as *D. rugosus* and *D. riograndensis* .