

= Saurolophus =

Saurolophus (/ s??r?l?f?s / ; meaning " lizard crest ") is a genus of large saurolophine hadrosaurid dinosaurs that lived about 70 @. @ 0 ? 68 @. @ 5 million years ago , in the Late Cretaceous of North America and Asia ; it is one of the few genera of dinosaurs known from multiple continents . It is distinguished by a spike @-@ like crest which projects up and back from the skull . Saurolophus was a herbivorous dinosaur which could move about either bipedally or quadrupedally .

The type species , *S. osborni* , was described by Barnum Brown in 1912 from Canadian fossils . A second valid species , *S. angustirostris* , is represented by numerous specimens from Mongolia , and was described by Anatoly Konstantinovich Rozhdestvensky .

= = Description = =

Saurolophus is known from material including nearly complete skeletons , giving researchers a clear picture of its bony anatomy . *S. osborni* , the rarer Albertan species , was around 9 @. @ 8 m (32 ft) long , with its skull 1 @. @ 0 m (3 @. @ 3 ft) long . Its weight is estimated at 1 @. @ 9 tonnes (2 @. @ 1 tons) . *S. angustirostris* , the Mongolian species , was larger ; the type skeleton is roughly 12 m (39 ft) long , and larger remains are reported . Aside from size , the two species are virtually identical , with differentiation hindered by lack of study .

The most distinctive feature of Saurolophus is its cranial crest , which is present in young individuals , but is smaller . It is long and spike @-@ like and projects upward and backward at about a 45 ° angle , starting from over the eyes . This crest is often described as solid , but appears to be solid only at the point , with internal chambers that may have had a respiratory and / or heat @-@ regulation function .

The holotype of *S. angustirostris* is a skull and postcrania , so the cranium of the species is well @-@ described . Bell et al. re @-@ evaluated the entire species in a 2011 publication with *Acta Palaeontologica Polonica* . Their description found the skull to be generalized among hadrosaurines , and are much larger than any skulls of *S. osborni* . The most unusual feature for a hadrosaurine is the long , protruding , solid crest that extends upwards diagonally from the back of the skull roof . Unlike lambeosaurines , the crests are made up completely of the nasal bone . The premaxilla bones make up almost 50 % of the entire skull length , and both sides are filled with small holes . Only in adult individuals has the front of the premaxillary contact been fused . Longer than the premaxilla , the nasal bones are the longest in the skull . They make up the entire length of the crest , and are never preserved as fused .

= = Classification = =

Barnum Brown , who described the first specimens , put it in its own subfamily in " Trachodontidae " (= Hadrosauridae) , the Saurolophinae . At the time , this also included *Corythosaurus* and *Hypacrosaurus* , the only well @-@ known examples of what would become the Lambeosaurinae . Brown thought that Saurolophus had an expanded tip to the ischium bone in the hip , as dinosaurs now recognized as lambeosaurines had , but this appears to have been based on a mistakenly associated lambeosaurine ischium . Additionally , he misinterpreted the crests of Saurolophus and lambeosaurines as being made of the same bones .

Most publications before 2010 classified Saurolophus as a member of Hadrosaurinae , often known colloquially as the " flat @-@ headed hadrosaurs " . In 2010 , the subfamily Saurolophinae was brought back into use because Hadrosaurus appears to have branched off prior to the " hadrosaurine " ? lambeosaurine split . As a result , Hadrosaurinae by definition cannot include the traditional " hadrosaurines " . Saurolophinae is the oldest available name for the former " hadrosaurine " clade . Saurolophus , as the name suggests , is a saurolophine , as it has a saurolophine pelvis and a (largely) solid crest .

The following cladogram of hadrosaurid relationships was published in 2013 by Alberto Prieto @-@

= = Discovery and history = =

Barnum Brown recovered the first described remains of *Saurolophus* in 1911 , including a nearly complete skeleton (AMNH 5220) . Now on display in the American Museum of Natural History , this skeleton was the first nearly complete dinosaur skeleton from Canada . It was found in rocks of early Maastrichtian age , in the Upper Cretaceous Horseshoe Canyon Formation (then known as the Edmonton Formation) near Tolman Ferry on the Red Deer River in Alberta . Brown wasted little time in describing his material , giving it its own subfamily . *Saurolophus* was an important early reference for other hadrosaurs , as seen in the names of *Prosaurolophus* (" before *Saurolophus* ") and *Parasaurolophus* (" near *Saurolophus* ") . However , little additional material has been recovered and described .

Instead , more abundant remains from Asia have provided more data . Initial remains were not promising ; a partial fragmentary ischium from Heilongjiang , China , that Riabinin named *S. kryshtofovici* . Much better remains were soon recovered , though , but from Mongolia 's early Maastrichtian @-@ age Nemegt Formation . The 1946 ? 1949 Russian @-@ Mongolian paleontological expeditions recovered the large skeleton that became *S. angustirostris* as described by Anatoly Rozhdestvensky . Other skeletons from a variety of growth stages have also been discovered , and *S. angustirostris* is now the most abundant Asian hadrosaurid .

In 1939 ? 40 , two partial skeletons were found in the late Maastrichtian age Moreno Formation of California . These specimens were referred to cf . *Saurolophus* sp . In 2010 , one of the skulls was instead assigned to *Edmontosaurus* . A 2013 placed the two specimens in a new species , *S. morrisoni* . In 2014 , the species was reassigned to a new genus , *Augustynolophus* .

= = = Species = = =

Two species are regarded as valid today : the type species *S. osborni* , and *S. angustirostris* . *S. osborni* (Brown , 1912) is known from a skull and skeleton , two other complete skulls , and skull fragments . *S. angustirostris* (Rozhdestvensky , 1952) is known from at least 15 specimens . It differs from *S. osborni* by some details of the skull , as well as in the pattern of scales found in skin impressions . The Mongolian species had a longer skull (by 20 %) and the front of the snout (the premaxillary bones) were more upwardly directed . *S. angustirostris* also had a distinctive row of square scales along the back and tail , which was smooth in *S. osborni* . In *S. angustirostris* , the scales on the tail flank were arranged in vertical patterns , which may have corresponded to striped coloration in life . This area was covered in radial scale patterns in *S. osborni* , possibly indicating a more mottled or spotted coloration . *S. kryshtofovici* (Riabinin , 1930) is not considered valid ; either it is regarded as a dubious name , or as a synonym of *S. angustirostris* (although the name antedates *S. angustirostris*) .

Until a 2011 reevaluation of the species by Phil R. Bell , *S. angustirostris* was not well @-@ described . No autapomorphies , unique derived traits , had been established distinguishing it from *S. osborni* . Bell found in a publication earlier in the year that the two previous studies of *S. angustirostris* , by Rozhdestvensky in 1952 , and Maryanska and Osmolska in 1981 , do not provide a comprehensive enough description to compare the species with *S. osborni* .

= = Paleoecology = =

S. osborni is known only from the upper part (unit 4) of the Horseshoe Canyon Formation . It lived alongside other dinosaur species including the ornithomimids *Hypacrosaurus altispinus* and *Parksosaurus warreni* , ankylosaurid *Anodontosaurus lambei* , pachycephalosaurid *Sphaerolithus edmontonense* , ornithomimids *Ornithomimus breviterius* and an unnamed species of *Struthiomimus* , small theropods including *Atrociraptor marshalli* and *Albertonykus borealis* , and the tyrannosauroid *Albertosaurus sarcophagus* . The dinosaurs from this formation form part of the

Edmontonian land vertebrate age . The Horseshoe Canyon Formation is interpreted as having a significant marine influence , due to an encroaching Western Interior Seaway , the shallow sea that covered the midsection of North America through much of the Cretaceous . *S. osborni* may have preferred to stay inland . A 2001 study suggested that *Saurolophus osborni* was part of a distinct inland fauna characterized by an association between *Anchiceratops ornatus* and it , while the contemporary coastal fauna was characterized by the association of *Pachyrhinosaurus canadensis* and *Edmontosaurus regalis* . However , the association between *S. osborni* and *Anchiceratops* was later noted to be in error , *Anchiceratops* only occurs lower in the Horseshoe Canyon Formation , before the major transgression of the Western Interior Seaway represented by the Drumheller Marine Tongue .

S. angustirostris was one of the largest herbivores of the Nemegt Formation , which lacked large horned dinosaurs , but had sauropods and a more diverse theropod fauna . It coexisted with the rare hadrosaurid *Barsboldia* , flat @-@ headed pachycephalosaurian *Homalocephale* and domed *Prenocephale* , the large ankylosaurid *Saichania* , rare saltasaurid sauropods *Nemegtosaurus* and *Opisthocoelicaudia* , the alvarezsaurid *Mononykus* , three types of troodontids including *Zanabazar* , several oviraptorosaurians including *Rinchenia* and *Nomingia* , the ostrich @-@ mimics *Gallimimus* and *Deinonychus* , therizinosaurid *Therizinosaurus* , tyrannosaurid relative *Bagaraatan* , and the tyrannosaurid *Tarbosaurus* . Unlike other Mongolian formations like the well @-@ known Djadochta Formation that includes *Velociraptor* and *Protoceratops* , the Nemegt is interpreted as being well @-@ watered , like the Dinosaur Park Formation in Alberta . When examined , the rock facies of the Nemegt formation suggest the presence of stream and river channels , mudflats , and shallow lakes . Sediments also indicate that a rich habitat existed , offering diverse food in abundant amounts that could sustain Cretaceous dinosaurs .

= = Paleobiology = =

As a hadrosaurid , *Saurolophus* would have been a bipedal / quadrupedal herbivore , eating a variety of plants . Its skull permitted a grinding motion analogous to chewing , and its teeth were continually replacing and packed into dental batteries that contained hundreds of teeth , only a relative handful of which were in use at any time . Plant material would have been cropped by its broad beak , and held in the jaws by a cheek @-@ like organ . Its feeding range would have extended from the ground to about 4 m (13 ft) above . Common *S. angustirostris* would have been an important large herbivore in the Nemegt Formation , but *S. osborni* was rare in the Horseshoe Canyon Formation and faced competition from other duckbills (genus *Hypacrosaurus*) . Comparisons between the scleral rings of *Saurolophus* and modern birds and reptiles suggest that it may have been cathemeral , active throughout the day at short intervals .

= = = Crest = = =

The distinctive spike @-@ like crest of *Saurolophus* has been interpreted in multiple ways , and could have had multiple functions . Brown compared it to the crest of a chameleon , and suggested it could provide an area for muscle attachment and a connection point for a nonbody back frill like that seen in the basilisk lizard . Peter Dodson interpreted similar features in other duckbills as having use in sexual identification . Maryanska and Osmólska , noting the hollow base , suggested that the crest increased the surface area of the respiratory cavity , and helped in thermoregulation . James Hopson supported a function as a visual signal , and further mentioned the possibility that the inflatable skin flaps over the nostrils could have acted as resonators and additional visual signals . This idea has been picked up by authors of popular dinosaur works , such as David B. Norman , who discussed hadrosaurid display at length and included a life restoration of such an adaptation in action .

The unique crest of *Saurolophus* is made up almost completely by the nasal bones , and in *S. angustirostris* it is solid . In adult specimens the crests are a rounded triangular shape in cross section . The crest protrudes past the edge of the skull backwards . Thin processes from the frontals

and prefrontals extend along the underside of the crest , probably to strengthen it . At the end of the crest is a swelling of the nasal , which is often termed differently .

= = = Ontogeny = = =

Though the growth rates of Saurolophus are poorly understood , a group of perinatal Saurolophus was recently discovered in an area of the Gobi Desert known as " The Dragon 's Tomb " . The animals uncovered had skull lengths less than five percent of the length of the skulls of the adults , indicating they were in the earliest developmental stage at the time of their deaths The discovery of Saurolophus neonates also indicates the distinct crest found in adults was poorly developed in infancy . It remains unknown if the animals were still within their eggs or if they had hatched before they died . The specimens were described in the journal PLOS ONE on October 14 , 2015 by Leonard Dewaele et al .