= Lambeosaurus =

Lambeosaurus (/ ?læmbio??s??r?s / LAM @-@ bee @-@ o @-@ SAWR @-@ ?s ; meaning " Lambe 's lizard ") is a genus of hadrosaurid dinosaur that lived about 75 million years ago , in the Late Cretaceous period (Campanian) of North America . This bipedal / quadrupedal , herbivorous dinosaur is known for its distinctive hollow cranial crest , which in the best @-@ known species resembled a hatchet . Several possible species have been named , from Canada , the United States , and Mexico , but only the two Canadian species are currently recognized as valid .

Lambeosaurus was belatedly described in 1923 by William Parks , over twenty years after the first material was studied by Lawrence Lambe . The genus has a complicated taxonomic history , in part because small @-@ bodied crested hadrosaurids now recognized as juveniles were once thought to belong to their own genera and species . Currently , the various skulls assigned to the type species L. lambei are interpreted as showing age differences and sexual dimorphism . Lambeosaurus was closely related to the better known Corythosaurus , which is found in slightly older rocks , as well as the less well @-@ known genera Hypacrosaurus and Olorotitan . All had unusual crests , which are now generally assumed to have served social functions like noisemaking and recognition .

= = Description = =

Lambeosaurus , best known through L. lambei , was quite similar to Corythosaurus in everything but the form of the head adornment . Compared to Corythosaurus , the crest of Lambeosaurus was shifted forward , and the hollow nasal passages within were at the front of the crest and stacked vertically . It also can be differentiated from Corythosaurus by its lack of forking nasal processes making up part of the sides of the crest , which is the only way to tell juveniles of the two genera apart , as the crests took on their distinctive forms as the animals aged .

Lambeosaurus was like other hadrosaurids , and could move on both two legs and all fours , as shown by footprints of related animals . It had a long tail stiffened by ossified tendons that prevented it from drooping . The hands had four fingers , lacking the innermost finger of the generalized five @-@ fingered tetrapod hand , while the second , third , and fourth fingers were bunched together and bore hooves , suggesting the animal could have used the hands for support . The fifth finger was free and could be used to manipulate objects . Each foot had only the three central toes .

The most distinctive feature , the crest , was different in the two well @-@ known species . In L. lambei , it had a hatchet @-@ like shape when the dinosaur was full @-@ grown , and was somewhat shorter and more rounded in specimens interpreted as females . The " hatchet blade " projected in front of the eyes , and the " handle " was a solid bony rod that jutted out over the back of the skull . The " hatchet blade " had two sections : the uppermost portion was a thin bony " coxcomb " that grew out relatively late in life , when an individual neared adulthood ; and the lower portion held hollow spaces that were continuations of the nasal passages . In L. magnicristatus , the " handle " was greatly reduced , and the " blade " expanded , forming a tall , exaggerated pompadour @-@ like crest . This crest is damaged in the best overall specimen , and only the front half remains .

The Canadian species of Lambeosaurus appear to have been similar in size to Corythosaurus , and thus around 9 @.@ 4 m (31 ft) long . Impressions of the scales are known for several specimens ; a specimen now assigned to L. lambei had a thin skin with uniform , polygonal scutes distributed in no particular order on the neck , torso , and tail . Similar scalation is known from the neck , forelimb , and foot of a specimen of L. magnicristatus .

= = Classification = =

Lambeosaurus is the type genus of the Lambeosaurinae , the subfamily of hadrosaurids that had hollow skull crests . Among the lambeosaurines , it is closely related to similar dinosaurs such as Corythosaurus and Hypacrosaurus , with little separating them but crest form . The relationships among these dinosaur genera are difficult to pick out . Some early classifications placed these

genera in the tribe Corythosaurini , which was found by David Evans and Robert Reisz to include Lambeosaurus as the sister taxon to a clade made up of Corythosaurus , Hypacrosaurus , and the Russian genus Olorotitan ; these lambeosaurines , with Nipponosaurus . However , later researchers pointed out that due to the rules of priority set forth by the ICZN , any tribe containing Lambeosaurus is properly named Lambeosaurini , and that therefore the name " Corythosaurini " is a junior synonym . The following cladogram illustrating the relationships of Lambeosaurus and its close relatives was recovered in a 2012 phylogenetic analysis by Albert Prieto @-@ Márquez , Luis M. Chiappe and Shantanu H. Joshi .

= = Discovery and history = =

Lambeosaurus has a complicated taxonomic history , beginning in 1902 with Lawrence Lambe 's naming of hadrosaurid limb material and other bones (originally GSC 419) from Alberta as Trachodon marginatus . Paleontologists began finding better remains of hadrosaurids from the same rocks in the 1910s , in what is now known as the late Campanian @-@ age (Upper Cretaceous) Dinosaur Park Formation . Lambe assigned two new skulls to T. marginatus , and based on the new information , coined the genus Stephanosaurus for the species in 1914 . Unfortunately , there was very little to associate the skulls with the scrappy earlier marginatus material , so in 1923 William Parks proposed a new genus and species for the skulls , with both generic and specific names honoring Lambe : Lambeosaurus lambei (type specimen NMC 2869 , originally GSC 2869) .

= = = New species and procheneosaurs = = =

Although the early workers in Alberta did not recognize it at the time , they were finding the remains of juvenile Lambeosaurus as well . These fossils of small @-@ bodied crested duckbills were interpreted as adults of a distinct lineage of hadrosaurids , the subfamily Cheneosaurinae . The first such animal to be named was Trachodon altidens , a left upper jaw (GSC 1092) from the Dinosaur Park Formation described by Lawrence Lambe in 1902 . In the same volume , Henry Fairfield Osborn suggested T. altidens could belong to a new genus , which he labelled Didanodon without further discussion . In 2006 , Lund and Gates stated that Didanodon altidens was a nomen nudum , without further discussion .

In 1920 , William Diller Matthew used the name Procheneosaurus (no species name) in a caption for a photograph of a skeleton at the American Museum of Natural History , from the Dinosaur Park Formation (AMNH 5340) . Parks believed that the procedure and description were inadequate for the name to be considered valid , and to address the situation , he coined the genus Tetragonosaurus . Into this genus he placed the type species T. praeceps (based on ROM 3577) and a second species T. erectofrons (based on ROM 3578) for small skulls from the Dinosaur Park Formation , and assigned Matthew 's Procheneosaurus skeleton to T. praeceps . Charles M. Sternberg followed in 1935 by adding the slightly larger T. cranibrevis , based on GSC (now NMC) 8633 . The use of Tetragonosaurus was rejected by Richard Swann Lull in favor of Procheneosaurus . Lull requested that the name Tetragonosaurus be suppressed in favor of Procheneosaurus , which was granted , and Procheneosaurus received official approval from the ICZN as a conserved name . In 1942 he and Wright transferred the Tetragonosaurus species and , tentatively , Trachodon altidens , to Procheneosaurus , with P. praeceps serving as the type species . This usage was generally followed until 1975 , when Peter Dodson showed that the " cheneosaurs " were actually juveniles of other dinosaurs . Procheneosaurus praeceps and altidens are considered probable synonyms of Lambeosaurus lambei .

P. cranibrevis , from the Dinosaur Park Formation and named as a species of Tetragonosaurus in 1935 by Charles M. Sternberg , was slightly larger than the other species , and was interpreted by Dodson as a juvenile Corythosaurus . Further study has shown that the type specimen is a Lambeosaurus juvenile , based on how the skull bones articulate , and that several other specimens assigned to it are Corythosaurus . P. erectofrons , named by Parks as a species of Tetragonosaurus , is based on a skull from the Dinosaur Park Formation . Dodson found it to be a juvenile

Corythosaurus casuarius , although one distinct skeleton from the late Campanian @-@ age Upper Cretaceous Two Medicine Formation of Montana , USA , appears to belong to a young Hypacrosaurus stebingeri .

" P. " convincens , from the Late Cretaceous of Kazakhstan , is known from a nearly complete skeleton missing only the snout and end of the tail . It was named by A. K. Rozhdestvensky in 1968 . It has at times been considered synonymous with Jaxartosaurus aralensis , or deserving of its own genus . Bell and Brink (2013) made " P. " convincens the type species of the new genus Kazaklambia .

The " procheneosaurs " weren 't the only crested duckbills being studied and named in the early 1900s . It was then the accepted practice to name genera and species for what is now seen as more likely individual variation , variation due to age or sex , or distortion from fossilization . Three more species were named during this period that relate to Lambeosaurus , all in 1935 . Sternberg , in the same paper as T. cranibrevis , named a skull and partial skeleton (GSC ? now NMC ? 8705) L. magnicristatum (corrected to magnicristatus) , and a smaller skull (GSC ? now NMC ? 8703) L. clavinitialis , with a less prominent crest and reduced spine pointing from the back . Parks contributed Corythosaurus frontalis , based on skull GSC 5853 (now ROM 869) , which differed from the well @-@ known tall , straight , rounded crest of other specimens of Corythosaurus by having a low crest cocked forward .

= = = Reconsideration and consolidation = = =

New specimens were not described for many years following the activity of the early 1900s . In 1964 John Ostrom noted that an old species named by Othniel Charles Marsh , Hadrosaurus paucidens , based on USNM 5457 , a partial maxilla and squamosal from the Judith River Formation of Fergus County , Montana , was probably a specimen of Lambeosaurus .

In 1975 , Peter Dodson , examining why there should be so many species and genera of lambeosaurine duckbills within such a short geological time frame and small area , published the results of a morphometric study in which he measured dozens of skulls . He found that many of the species had been based on remains that were better interpreted as juveniles or different sexes . For Lambeosaurus , he found that L. clavinitialis was probably the female of L. lambei , and Corythosaurus frontalis and Procheneosaurus praeceps were probably its juveniles . L. magnicristatus was different enough to warrant its own species . He interpreted Procheneosaurus cranibrevis and P. erectofrons as juvenile corythosaurs . However , restudy of the Procheneosaurus / Tetragonosaurus remains indicates that within species , assignments had become confused , and the type specimen of P. cranibrevis was a Lambeosaurus juvenile , whereas others were Corythosaurus , based on the distinctive form of the contact of the nasal bone with the premaxilla .

Also during the 1970s , Bill Morris was studying giant lambeosaurine remains from Baja California . He named them ? L. laticaudus in 1981 (type specimen LACM 17715) . Morris used a question mark in his work because no complete crest had been found for his species , and without it a definitive assignment could not be made . From what was known of the skull , he considered it to be most like Lambeosaurus . He interpreted this species as water @-@ bound , due to features like its size , its tall and narrow tail (interpreted as a swimming adaptation) , and weak hip articulations , as well as a healed broken thigh bone that he thought would have been too much of a handicap for a terrestrial animal to have survived long enough to heal . This species was later (2012) assigned to the new genus Magnapaulia .

= = Species = =

Two species of Lambeosaurus are currently confirmed valid , with a third sometimes accepted . L. lambei (Parks , 1923) is known from at least 17 individuals , with seven skulls and partial skeletons and around ten isolated skulls . L. clavinitialis (C.M. Sternberg , 1935) , Corythosaurus frontalis (Parks , 1935) , and Procheneosaurus praeceps (Parks , 1931) are all regarded as synonyms of L. lambei in the most recent review . It is possible that L. clavinitialis skulls without the backward spine

may represent L. magnicristatus individuals instead , although this was rejected in the 2007 redescription of L. magnicristatus . L. magnicristatus (C.M. Sternberg , 1935) is only definitely known from two specimens , both with skulls . Unfortunately , the majority of the articulated skeleton of the type specimen has been lost . Many of the bones were extensively damaged by water while in storage and were discarded before description ; other portions of this skeleton have also been lost . Its remains come from slightly younger rocks than L. lambei . The specific name is derived from the Latin magnus " large " and cristatus " crested " , referring to its bony crest . Additionally , Jack Horner has identified fragmentary lambeosaurine jaws from the Bearpaw Formation of Montana as possibly belonging to L. magnicristatus ; these represent the first lambeosaurine remains from marine rocks . As noted above , the large " L. " laticaudus (Morris , 1981) was assigned to Magnapaulia .

L. paucidens (Marsh , 1889) is regarded as a dubious name and is listed as Hadrosaurus paucidens in the latest review , although at least one author , Donald F. Glut , accepts it as a species of Lambeosaurus . In this case , the specific epithet is derived from the Latin pauci- " few " and dens " tooth " . The irregularities of Procheneosaurus cranibrevis , and the identity of the type as a juvenile lambeosaur , were recognized in 2005 , and thus have not yet entered wide circulation . Finally , Didanodon altidens has been assigned without comment to Lambeosaurus in two 21st Century reviews .

= = Paleoecology = =

Lambeosaurus lambei and L. magnicristatus , from the Dinosaur Park Formation , were members of a diverse and well @-@ documented fauna of prehistoric animals that included such well @-@ known dinosaurs as the horned Centrosaurus , Styracosaurus , and Chasmosaurus , fellow duckbills Prosaurolophus , Gryposaurus , Corythosaurus , and Parasaurolophus , tyrannosaurid Gorgosaurus , and armored Edmontonia and Euoplocephalus . The Dinosaur Park Formation is interpreted as a low @-@ relief setting of rivers and floodplains that became more swampy and influenced by marine conditions over time as the Western Interior Seaway transgressed westward . The climate was warmer than present @-@ day Alberta , without frost , but with wetter and drier seasons . Conifers were apparently the dominant canopy plants , with an understory of ferns , tree ferns , and angiosperms . The anatomically similar L. lambei , L. magnicristatus , and Corythosaurus were separated by time within the formation , based on stratigraphy . Corythosaurus fossils are known from the lower two @-@ thirds of the Formation , L. lambei fossils are present in the upper third , and L. magnicristatus remains are rare and present only at the very top , where the marine influence was greater .

= = Paleobiology = =

= = = Feeding = = =

As a hadrosaurid , Lambeosaurus was a large bipedal / quadrupedal herbivore , eating plants with a sophisticated skull that permitted a grinding motion analogous to mammalian chewing . Its teeth were continually replaced and were packed into dental batteries that each contained over 100 teeth , only a relative handful of which were in use at any time . It used its beak to crop plant material , which was held in the jaws by a cheek @-@ like organ . Feeding would have been from the ground up to around 4 meters (13 feet) above . As noted by Bob Bakker , lambeosaurines have narrower beaks than hadrosaurines , implying that Lambeosaurus and its relatives could feed more selectively than their broad @-@ beaked , crestless counterparts .

= = = Cranial crest = = =

Like other lambeosaurines such as Parasaurolophus and Corythosaurus , Lambeosaurus had a

distinctive crest on the top of its head . Its nasal cavity ran back through this crest , making it mostly hollow . Many suggestions have been made for the function or functions of the crest , including housing salt glands , improving the sense of smell , use as a snorkel or air trap , acting as a resonating chamber for making sounds , or being a method for different species or different sexes of the same species to recognize each other . Social functions such as noisemaking and recognition have become the most widely accepted of the various hypotheses .

The large size of hadrosaurid eye sockets and the presence of sclerotic rings in the eyes imply acute vision and diurnal habits , evidence that sight was important to these animals . The hadrosaurid sense of hearing also appears to be strong . There is at least one example , in the related Corythosaurus , of a slender stapes (reptilian ear bone) in place , which combined with a large space for an eardrum implies a sensitive middle ear , and the hadrosaurid lagena is elongate like a crocodilian 's . This indicates that the auditory portion of the inner ear was well @-@ developed . If used as a noisemaker , the crest could also have provided recognizable differences for different species or sexes , because the differing layouts of the nasal passages corresponding to the different crest shapes would have produced intrinsically different sounds .