

= Dinheirosaurus =

Dinheirosaurus is a genus of diplodocid sauropod dinosaur that is known from fossils uncovered in modern @-@ day Portugal . It may represent a species of Supersaurus . The only species is Dinheirosaurus lourinhanensis , first described by José Bonaparte and Octávio Mateus in 1999 for vertebrae and some other material from the Lourinhã Formation . Although the precise age of the formation is not known , it can be dated around the early Tithonian of the Late Jurassic .

The known material includes two cervical vertebrae , nine dorsal vertebrae , a few ribs , a fragment of a pubis , and many gastroliths . Of the material , only the vertebrae are diagnostic , with the ribs and pubis being too fragmentary or general to distinguish Dinheirosaurus . This material was first described as in the genus Lourinhasaurus , but differences were noticed and in 1999 Bonaparte and Mateus redescribed the material under the new binomial Dinheirosaurus lourinhanensis . Another specimen , ML 418 , thought to be Dinheirosaurus , is now known to be from another Portuguese diplodocid . This means that Dinheirosaurus lived alongside many theropods , sauropods , thyreophorans and ornithopods , as well as at least one other diplodocid .

Dinheirosaurus is a diplodocid , a relative of Apatosaurus , Diplodocus , Barosaurus , Supersaurus , and Tornieria . Among those , the closest relative to Dinheirosaurus is Supersaurus , and together they form a clade of primitive diplodocids . While they were once considered to be diplodocines they are likely more basal than Apatosaurus .

= = Discovery and naming = =

ML 414 was first uncovered in 1987 by Mr. Carlos Anunciação . He was associated with the Museu da Lourinhã , and after the excavations which lasted from the time of discovery until 1992 , the specimen was then moved in to the museum , and catalogued under the number 414 . Dantas et al. preliminarily announced ML 414 as soon as the excavations were complete . To remove the fossils from the surrounding rock , a bulldozer and tilt hammer were needed . The fossils were situated at the top of a costal cliff , and once removed , were shipped to Lourinhã in two blocks with the help of a crane . A year before being described as a new taxon , Dantas et al. assigned ML 414 to Lourinhasaurus alenquerensis , previously grouped under Apatosaurus . José Bonaparte and Octávio Mateus studied the material of Lourinhasaurus , concluding one specimen , under the name ML 414 , to be more closely related to diplodocids of the Morrison Formation , and thus warranting a new binomial name . This new species was described as Dinheirosaurus lourinhanensis , with a full meaning of " Porto Dinheiro lizard from Lourinhã " .

Dinheirosaurus material included vertebrae , ribs , partial pelvis , and gastroliths . The vertebrae were certainly from the cervical and dorsal regions , and are articulated . The two cervicals are not greatly preserved , although the twelve dorsals are articulated and in good condition . Other vertebral material includes seven centra that are fragmentary and a few neural arches , which are unattached . 12 dorsal ribs are preserved , as well as some appendicular elements . David Weishampel et al. did not recognize all the material as belonging to Dinheirosaurus , and only found 9 dorsals in the holotype , while also misinterpreting the pubis as a limb fragment . They also incorrectly stated that it was found in the Camadas de Alcobaça Formation . Another pair of vertebrae , under collection number ML 418 , was originally assigned to Dinheirosaurus by Bonaparte and Mateus , but is now considered to be a distinct new unnamed genus of diplodocid .

= = Description = =

Dinheirosaurus is an average sized diplodocid , and had an elongated neck and tail . The main features of the genus are based on its vertebral anatomy , and multiple vertebrae from across the spine have been found . In total , Dinheirosaurus would have had an approximate length of 25 m (82 ft) .

Dinheirosaurus is not known well from non @-@ vertebral material , currently only consisting of partial ribs and a fragment of a pelvis . One of the ribs attached to the cervicals , and is quite

fragmentary . It is elongated , although that might be a feature of distortion . Also undescribed by Bonaparte & Mateus are a set of thoracic ribs . Two ribs are from the left side of the animal . They are T @-@ shaped in cross section , and display plesiomorphic features , although their incomplete state makes their identification uncertain . Multiple right ribs are preserved , including both the shafts and heads . They are similar to the left ribs , which also show that they lack pneumaticization . Other appendicular (non @-@ vertebral) material includes a very incomplete and fragmentary shaft of the pubis , and over one hundred gastroliths . The pubis displays practically no anatomical features , and the gastroliths were not described in detail by Mannion et al. in 2012 .

= = = Vertebrae = = =

The most distinguishing material of *Dinheirosaurus* comes from the vertebrae , which are well represented and described . Of the cervicals , only two of the assumed fifteen are preserved . According to Bonaparte & Mateus (1999) , the cervicals would number 13 and 14 . Apparently cervical 15 was lost during the excavation and removal of the holotype and only specimen of *Dinheirosaurus* . As of the original description , the thirteenth cervical was only prepared on the lateroventral portion . The length of the centrum is 71 cm (28 in) , and the fourteenth cervical is quite similar overall . 63 cm (25 in) is the total measurement of the 14th cervicals centrum , which is well preserved , complete , and concave along the bottom edge . The neural of the spine , while compressed from above compared to the cervicals of *Diplodocus* , is massive , and projects upwards towards its posterior end .

A relatively complete series of dorsal vertebrae are known , which number one to seven . All of the dorsals , however , are distorted upwards due to their state of preservation . Bonaparte & Mateus (1999) noted that the position of the dorsals was not certain , and that in fact the first dorsal could have been the last cervical or even the second dorsal . A similar numbering was found in *Diplodocus* , with the first and second dorsals similar in anatomy to the last and second @-@ last cervical . The dorsal vary in length from the 58 cm (23 in) of the first dorsal to the 25 cm (9 @.@ 8 in) of the seventh , eight and ninth dorsals . Height in the vertebrae is also quite variable , with the shortest height being 51 cm (20 in) tall to 76 cm (30 in) tall , increasing from the first dorsal .

= = Classification = =

Dinheirosaurus is not extremely well known , and as a consequence , its phylogenetic position is not certain . In 2012 during a redescription of the taxon by Philip Mannion et al . , it was recovered , in both cladograms , to be sister species to *Supersaurus vivianae* and together forming the most basal diplodocines . A 2012 cladogram , published by Mannion et al. and using a modified matrix of Whitlock (2011) found that *Dinheirosaurus* was more primitive than *Torneria* and more derived than *Apatosaurus* . However , a cladogram from 2014 found that their group was supported , but in fact more primitive than *Apatosaurus* , and therefore outside *Diplodocinae* . In 2015 , *Dinheirosaurus lourinhanensis* was considered a species of *Supersaurus* in a new combination *S. lourinhanensis* . Their results are shown below .

Previously , *Dinheirosaurus* was classified within a *Diplodocidae* excluding *Apatosaurus* , for the differences anatomically are quite great . Bonaparte & Mateus found that a few features present suggested that *Dinheirosaurus* was more derived than *Diplodocus* , but plesiomorphic features also present conclude that they branched separately and *Dinheirosaurus* is not the descendant of *Diplodocus* . A 2004 study by Upchurch et al. found that *Dinheirosaurus* was an intermediate diplodocoid , along with *Cetiosauriscus* , *Amphicoelias* , and *Losillasaurus* .

= = Paleobiology = =

As a diplodocid , it is probable that *Dinheirosaurus* possessed a whip @-@ tail . If it did , it is likely that its tail could be used like a bullwhip , with supersonic speed . Being related to both *Apatosaurus* and *Diplodocus* , *Dinheirosaurus* probably possessed a squared snout . This means that it was

probably a non @-@ selective ground @-@ feeding sauropod .

== Digestion ==

Dinheirosaurus is one of relatively few sauropods for which gastroliths were found obviously alongside the type specimen . In 2007 , an experiment using Dinheirosaurus , Diplodocus (= Seismosaurus) , and Cedarosaurus tested if sauropods used their gastroliths in an avian @-@ style gastric mill . The analysis took into account that among the hundreds of sauropods found , gastroliths are only known from a few associated specimens . Authors chose to use the three sauropods with the most associated gastroliths , Dinheirosaurus , Diplodocus , and Cedarosaurus , because of the large amount of gastroliths found in birds . When birds were typically found to have 1 @.@ 05 % of their body weight gastroliths , the sauropod Diplodocus , which had the highest amount of gastroliths , only amassed to 0 @.@ 03 % body weight . This means that since the other sauropods Dinheirosaurus and Cedarosaurus had less gastroliths to body mass , an avian @-@ style gastric mill is unlikely to have evolved in sauropods , and they instead might have used gastroliths to absorb minerals .

== Paleoecology ==

Dinheirosaurus was one of many dinosaurs to have lived in the Lourinhã Formation during the Late Jurassic . Many theropods , sauropods , and especially ornithischians are also from the Lourinhã Formation , which contains a similar fauna to the North American Morrison Formation . Many theropods are known including an unnamed genus of abelisaurid ; the allosaurid Allosaurus europaeus ; the ceratosaurid Ceratosaurus dentisculatus ; the coelurosaurians Aviatyrannis jurassica , and cf . Richardoestesia ; an intermediate theropod ; and the megalosaurid Torvosaurus gurneyi . Sauropods are less common , with only an intermediate diplodocid as well as Dinheirosaurus ; the camarasaurid Lourinhasaurus alenquerensis ; the turiasaur Zby atlanticus ; and the brachiosaurid Lusotitan known . Ornithischians are well represented , with identified remains persisting to Trimucrodon cuneatus ; Alocodon kuehnei ; the stegosaurians Dacentrurus armatus , Miragaia longicollum , and Stegosaurus ungulatus ; the ankylosaurid Dracopelta zbyzskii ; the ornithopods Draconyx loureiroi , Camptosaurus sp . , Phyllodon henkelli , and cf . Dryosaurus sp .

== Biogeography ==

Many eusauropods , including Dinheirosaurus have been found in the Late Jurassic of Europe . The sauropods are from around the base of the Tithonian as based on the presence of Anchispirocyclina lusitanica . One sauropod , a diplodocid currently based on an unnamed specimen including vertebrae and some bones , is clearly different from Dinheirosaurus and Losillasaurus , confirming the presence of a least two and possibly more diplodocids in the Late Jurassic of Spain and Portugal . This is unique in the variety of diplodocoids in all Europe , with the only other genera possibly non @-@ diplodocoid (Cetiosauriscus) , or classified in Rebbachisauridae . This suggests that the biogeography of primitive sauropods is incomplete , with possible primitive eusauropods and diplodocids surviving in the Late Jurassic , potentially until the Berriasian .