Allosaurus Diversity: Exploring Its Four Known Species.

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Allosaurus life reconstruction. Photo credit: Total Dino.

The genus Allosaurus (Marsh, 1877) represents one of the most extensively studied theropod taxa of the Late Jurassic. Allosauroidea (Currie and Zhao 1994) was described as branch-based, including all theropods that are more closely related to *Allosaurus fragilis* than to either *Megalosaurus bucklandii* (Mantell 1827).

Allosaurus has at times been both regarded as monospecific, or having up to at least ten questionable or undescribed species, and only a few were accepted at any given time.

According to Burigo and Mateus, 2024, the diversity of Allosaurus is limited to three named species: *A. fragilis, A. europaeus*, and *A. jimmadseni*. However in December 2024, a fourth species, *A. anax*, was described by Andy D. Danison (and his team Mathew J. Wedel, Daniel E. Barta, Holly N. Woodward, Holley M. Flora, Andrew H. Lee, and Eric Snively).

This recent research has demonstrated greater taxonomic diversity within the genus, resulting in the recognition of four valid species. These species span a temporal and geographic range from the American West to the Iberian Peninsula, providing insight into allosaurid evolution, dispersal, and ecological partitioning during the Late Jurassic. *Allosaurus atrox, A. amplus, and A. lucasi* holotypes do not have distinct autapomorphies and therefore, are considered nomina dubia.

Allosaurus fragilis:

Allosaurus fragilis, the type species, was first described by Marsh in 1877 from the Morrison Formation of North America. Its stratigraphic occurrence spans approximately 155–145 Mya, with abundant remains recovered from Utah, Colorado, and Wyoming.

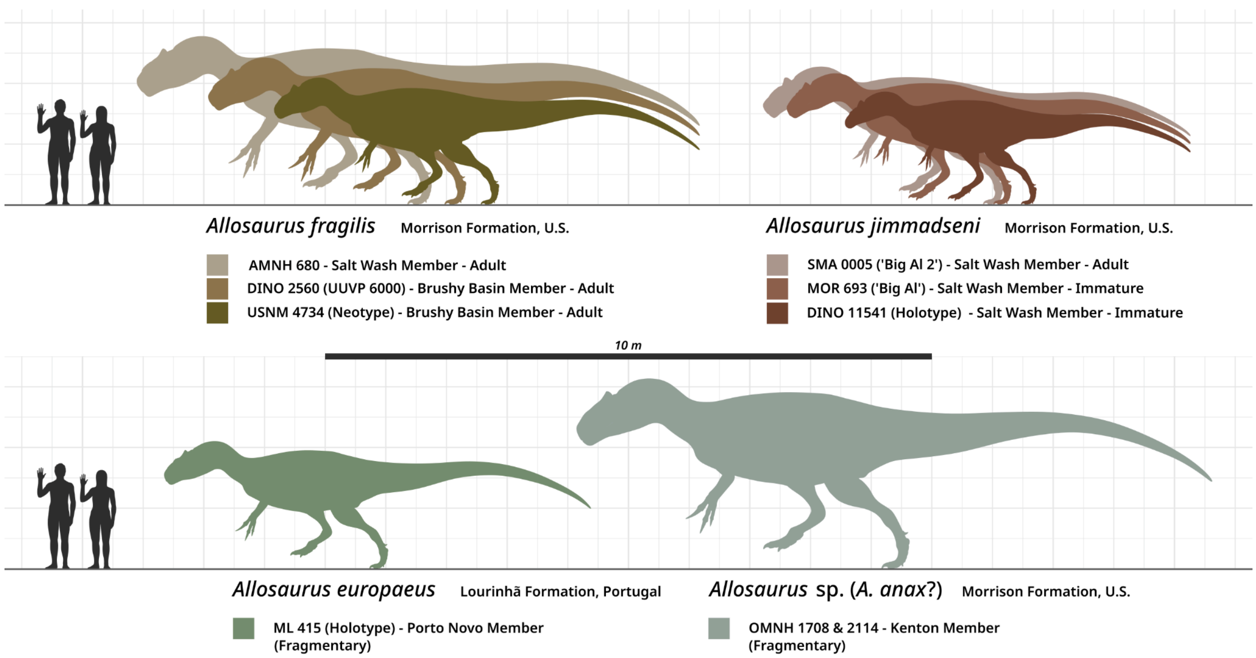
A. fragilis is characterized by a moderately broad skull, recurved maxillary and dentary teeth, and relatively gracile postcranial proportions. It has been reconstructed at lengths of 8–9 m, with some individuals approaching 10 m. The high abundance of specimens, including multiple individuals preserved at the Cleveland-Lloyd Dinosaur Quarry, suggests both ecological success and taphonomic bias.

Allosaurus jimmadseni:

Formally named in 2020 by Chure & Loewen, *Allosaurus jimmadseni* predates *A. fragilis* stratigraphically, with material recovered from the Salt Wash Member of the Morrison Formation in Utah and dating to 157–152 Mya. Thus, this was the first Allosaurus species to exist. However, approximately, 2 Mya later when *A. fragilis* appeared two species would have occurred.

Maidment, 2024,stated that both *A. fragilis* and *A. jimmadseni* are partly contemporaneous, with different geographical distributions, and with almost no overlap, where *A. fragilis* was found more south and east of the Morrison Basin and *A. jimmadseni* was found further north and west.

Diagnostic features on *A. jimmandseni* include a proportionally narrower skull, elongate lacrimal horns, and distinct jugal and surangular morphology. These traits distinguish it from the later-occurring fragilis and indicate evolutionary changes within North American allosaurids over several million years. The species epithet honors James H. Madsen Jr., who conducted foundational research on Allosaurus.



Size variation among the four Allosaurus species. Photo credit: Scott Hartman

Allosaurus europaeus:

Allosaurus europaeus, was described in 2006 by Mateus et al., extends the genus into the European realm. The validity of the species *A. europaeus* has been questioned by Malafaia et al., 2007, and Malafaia et al., again in 2010. It is stated that the original description is based on a set of characters falling within the morphological variability of *A. fragilis*, and it is possible that some features were misinterpreted. However, a detailed cranial description and specimen-based phylogeny were performed and resolved many of the open questions, and nine autapomorphies were found in *A. europaeus*, confirming the validity of the species (André Burigo and Octávio Mateus 2024).

Material of this species derives from the Lourinhã Formation of western Portugal, dated to approximately 150 Mya. Morphological comparisons reveal close affinities with *A. fragilis* but with diagnostic variation in cranial and axial elements, particularly in the maxilla and cervical vertebrae.

However, despite these morphological similarities, *A. europaeus* and *A. jimmadseni* are sister taxa and closer to each other than to *A. fragilis*.

The dispersal of Allosaurus into Europe (no later than Late Kimmeridgian) was after the phylogenetic split between *A. jimmadseni* and *A. europaeus*.

According to Burigo and Mateus, 2024, *Allosaurus europaeus* differs from *Allosaurus fragilis* in the pinched crest present on the dorsolateral edge of the nasal bone, in the very pronounced lacrimal horns (20% or more of the height in lateral view), in the sizes of the nasal pneumatic foramina (posterior larger than anterior), and in the very small accessory laminae present in the 4th and 5th cervical vertebrae. *Allosaurus europaeus* differs from *Allosaurus jimmadseni* in its curved jugal ventral margin, its sigmoidal jugal, and in the number of surangular posterior foramina. *Allosaurus europaeus* differs from both *A. fragilis* and *A. jimmadsen*i in its step-like maxilla ventroposterior end, in the lacrimal portion overlapping the nasal bone dorsally(when compared with DINO 2560, not preserved in USNM 4734), in the interrupted lacrimal latero-anterior vertical projection, in the postorbital sigmoidal contact with the jugal bone, in the ectopterygoid projection of the pterygoid (when compared with DINO 2560), and in the contribution of the pterygoid in the quadrate pterygoid flange fold (when compared with DINO 2560).

The presence of *A. europaeus* in Europe supports paleobiogeographic models of faunal interchange between North America and Iberia during the Late Jurassic, likely facilitated by ephemeral land connections across the proto-North Atlantic.

This is further exemplified by the fact that although the Morrison and Lourinhã formations are separated by sea, they share major clades of dinosaurs, indicating a fauna exchange between North America and Iberia. The Allosaurus genus is included in this exchange.

The diversity hotspot of Allosaurus is clearly in North America, suggesting that the genus originated and proliferated first in North America, as the hotspot genetic diversity is normally associated with the origin of the species. This, however, has never been tested for genus-level and deep-time vertebrate paleontology (André Burigo and Octávio Mateus 2024).

Allosaurus anax:

The most recently recognized species, *Allosaurus anax*, was described in 2024. *A. anax* is the result of research and reassessment of remains previously described as *Saurophaganax maximus*.

S. maximus is the designation of material attributed to a massive theropod dinosaur recovered from the Kenton 1 Quarry in the Morrison Formation of Oklahoma. However, some of the material from Quarry 1 previously assigned to *S. maximus* seems to represent an allosaurid diagnosably distinct from both *Allosaurus fragilis* and *Allosaurus jimmadseni*. Furthermore, reassessment of this material shows that some of the elements originally used to distinguish *Saurophaganax* from Allosaurus are more parsimoniously referred to diplodocid sauropods found in the same quarry rather than an allosaurid.

Additionally, the holotype neural arch cannot be confidently assigned to a theropod, making *Saurophaganax maximus* a nomen dubium. The presence of at least one skeletally mature theropod was confirmed through paleohistology of a fourth metatarsal. Despite the similarity of the decisively theropod material to known species of Allosaurus, some elements feature subtle autapomorphies that suggest they pertain to a distinct species, which was described as *Allosaurus anax*. Estimated mass of *A. anax* (4,634 kg, 3,871 kg, and 3,776 kg), based on circumferences of the three femora that likely belong to the species (OMNH 1371, OMNH 1708, and OMNH 2114 respectively) exceeds the maximum asymptotic body size that Prondvai (2017) estimated for *Allosaurus fragilis* by more than 1,500 kg (Andy D. Danison, Mathew J. Wedel, Daniel E. Barta, Holly N. Woodward, Holley M. Flora, Andrew H. Lee, and Eric Snively, 2024).

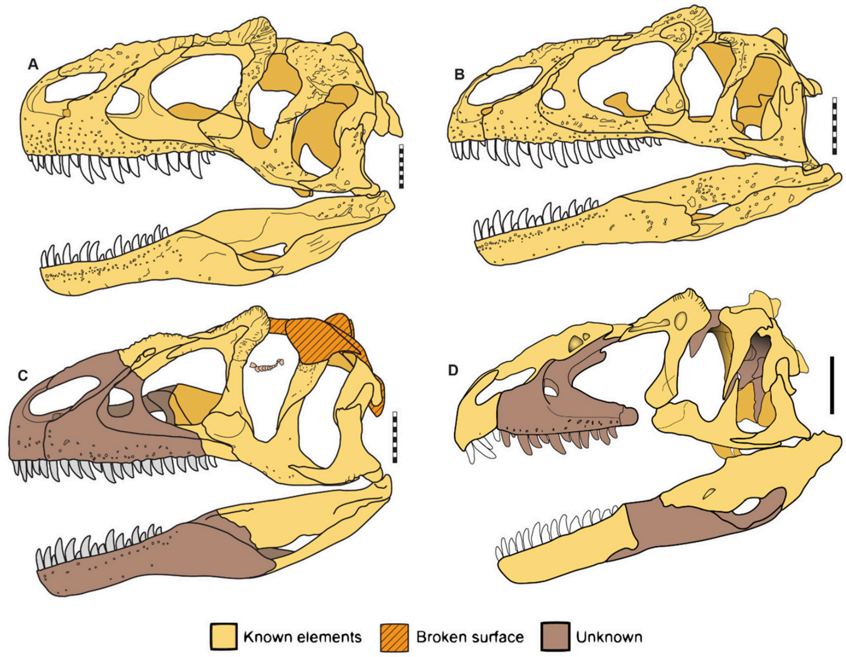
It is broadly coeval with *A. fragilis*, dating to 153–150 Mya. However, *A. anax* is distinguished by its more robust cranial morphology, reinforced vertebral structure, and large estimated body size, exceeding 11 m in some reconstructions. Its epithet (anax, "king") reflects this greater overall size. The sympatric occurrence of *A. fragilis* and *A. anax* suggests possible ecological niche partitioning among large theropods in the Morrison ecosystem. The sheer amount of *A. fragilis* material that has been uncovered suggests that this was the far more common form of Allosaurus.

At around 12.8 meters maximum length (Vividen: Paleontology Evolved, 2025) *A. anax* would have been the largest predatory dinosaur of the Jurassic period. Some authorities, though, state it was closer to 11 meters long, still making it the largest predator of the Jurassic (along with *Torvosaurus*).

A. anax, in addition with *Torvosaurus* and *Kayentapus*, represent the earliest examples of true megatheropods, giant predatory dinosaurs that would later include *Tyrannosaurus rex* and *Carcharodontosaurus* (Benson et al., 2010; Carrano et al., 2012). As a top predator, *A. anax* combined a powerful, yet lightly built frame with strong hindlimbs, grasping forearms, and a kinetic skull capable of wide-gape slashing bites. Such traits became hallmarks of many later large theropods (Bakker, 1998; Rayfield et al., 2001). Its role as an apex predator in a diverse ecosystem and its balanced combination of speed, power, and agility illustrate evolutionary strategies that were refined in later lineages of giant theropods during the Cretaceous (Brusatte et al., 2010). *Allosaurus anax* can be seen as a key evolutionary template, establishing the fundamental anatomical and ecological framework for the rise of later megatheropods across the globe.

Conclusions:

The recognition of four valid species of Allosaurus demonstrates that the genus was neither temporally nor morphologically uniform. *A. jimmadseni* represents an earlier, more gracile form, while *A. fragilis* and *A. anax* coexisted later in the Morrison Formation, possibly reflecting ecological differentiation. *A. europaeus* provides evidence of trans-Atlantic dispersal and diversification. Together, these taxa illustrate the evolutionary plasticity of allosaurids and underscore their importance as apex predators in Late Jurassic ecosystems.



Allosaurus species skull in lateral view, scale 10 cm. (A) A. fragilis DINO 2560, (B) A. jimmadseni DINO 1154, (C) A. europaeus ML415, and (D) interpretation of the new reconstitution of A. fragilis USNM 4734. (A–C). Photo credit: André Burigo, Octávio Mateus

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