

Lourinhasaurus n. gen. A new sauropod dinosaur from the Upper Jurassic (Upper Kimmeridgian-Lower Tithonian) of Portugal¹

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Key words: Kimmeridgian-Tithonian; Dinosauria; Sauropodomorpha; *Lourinhasaurus*; phylogeny; Portugal.

Abstract: The osteological study of fossilised remains (mostly articulated) of a large sauropod recovered from the Lourinhã Formation (Upper Kimmeridgian – Lower Tithonian), Praia de Porto Dinheiro outcrop (western side of the Lusitanian Basin, Portugal), is presented. The diagnostic characters present in this specimen diagnose it as *Apatosaurus alenquerensis*. However, analysis of these characters, especially of those of the first seven dorsal vertebrae, suggest placement of this material, and of other materials assigned to this species, in a new genus: *Lourinhasaurus* n. gen.

INTRODUCTION

Many osteological remains of sauropods are known from Portugal. The first scientific references of sauropods from the Mesozoic of Portugal date to the end of the 19th century (SAUVAGE, 1897-1898). Since then, several studies were based on this material (cf. DANTAS, 1990), despite the knowledge that the nation's sauropods were very incomplete.

In 1983 at Praia de Porto Dinheiro (Lourinhã, Portugal), in deposits of the Lourinhã Formation (Bacia Lusitânica; Upper Jurassic, Upper Kimmeridgian-Lower Tithonian), a skeleton of a large sauropod was uncovered, which was excavated successively in 1987, 1991 and 1992. A good part of the recovered skeleton was prepared and studied in 1993 (cf. DANTAS et al., 1992, 1993).

The characters presented by the Praia de Porto Dinheiro specimen, described and discussed in the present work, allowed it to be identified as *Apatosaurus alenquerensis* LAPPARENT & ZBYSZEWSKI, 1957. However, analysis of material attributed to this species, under several generic denominations, justify the formalization of a new genus - *Lourinhasaurus* n. gen.

SYSTEMATIC PALEONTOLOGY

Dinosauria OWEN, 1842

Saurischia SEELEY, 1887

Sauropodomorpha HUENE, 1932

Sauropoda MARSH, 1878

Incertae familiae *Lourinhasaurus* n. gen.

Apatosaurus: LAPPARENT & ZBYSZEWSKI, 1957, page. 33, non *Apatosaurus* MARSH, 1877.

?*Camarasaurus*: MCINTOSH, 1990, pág. 91, 349, 386, non *Camarasaurus* COPE, 1877.

Type Species: *Apatosaurus alenquerensis* LAPPARENT & ZBYSZEWSKI, 1957; Upper Jurassic of Bacia Lusitânica, Portugal.

Etymology: From Lourinhã, an area in west-central Portugal (Lisbon district) rich in remains of sauropod dinosaurs.

Diagnosis: Large sauropod with dorsal vertebrae exhibiting the following diagnostic characters: neural spines relatively tall, vertical and bifurcate; supradiapophyseal lamina very reduced; suprapostzygapophyseal lamina medium to small; postspinal lamina bifurcate and large; prespinal lamina large; lower portion of the low and extensive neural arch covering the whole centrum; constancy of characters on the lateral face

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of the lower part of the neural arch; existence of a branching accessory joint that originates on the inferior and lateral region of the neural arch and that “supports” the lateral expansion of the hyposphene; infrapariadiapophyseal lamina varying in size from small (first dorsal) to large (posterior dorsals); proportionally tall centra compared to the total height of the vertebrae; opisthocoelely present (also seen in the posterior cervical vertebrae); pleurocoels small to medium, elliptical, at times walled up. The posterior cervical vertebrae exhibit important longitudinal keels on the ventral face; these keels are small in the first ones and absent after the fifth (inclusive).

¹ Dantas, P., J. L. Sanz, C. M. da Silva, F. Ortega, V. F. dos Santos and M. Cachao. 1998. *Lourinhasaurus* n. gen. Novo dinossaurio sauropode do Jurássico superior (Kimeridgiano superior-Titoniano inferior) de Portugal. V Congresso Nacional de Geologia, Lisboa 91-94. Translated by Jerry D. Harris, June, 2002, using ABBYY FineScan 6.0 and L&H Power Translator 7.0 and BabelFish.

Comparison and Discussion: *Lourinhasaurus* n. gen. differs from *Brachiosaurus*, *Camarasaurus*, *Diplodocus* and *Dicraeosaurus*, in the dorsal vertebrae, by presenting a different ratio of "total height of the neural spines/height of the vertebrae" (35-46%), postspinal lamina very developed, lower part of the neural arch extensive and low, by possessing a bifurcate secondary articular process (that "supports" the lateral expansion of the hyposphene) and infrapariapophyseal lamina that increases progressively in size from the first through the posterior dorsal vertebrae (cf. HATCHER, 1901; RIGGS, 1904; OSBORN & MOOK, 1919, 1921; JANENSCH, 1929; GILMORE, 1932; JANENSCH, 1950a, 1950b; SALGADO & BONAPARTE, 1991).

Lourinhasaurus n. gen. bears similarities to *Camarasaurus* with its small suprapostzygapophyseal lamina, reduced supradiapophyseal lamina (a character also shared by *Dicraeosaurus*), by possessing secondary articular processes (in *Camarasaurus* this is not bifurcate), in its similar "total height of the centrum/height of the vertebrae" ratio (24-35%) and by possessing opisthocoely in the anterior dorsals (to D-4) but not subsequent ones (a character also shared by *Brachiosaurus*).

Lourinhasaurus n. gen. is similar to *Diplodocus* by possessing similar ligament insertion features on the lateral surface of the neural spine -- dorsoventrally high and with an extreme ventral angle -- and well developed prespinal lamina (in *Brachiosaurus*, however, it is much larger than in these two genera), in its constancy of the characters on the lateral faces from D-1 and D-7, by its posterior union of the infradiapophyseal and infrapariapophyseal laminae forming an marked angle, and by possessing an infrapariapophyseal lamina (which only appears in the fifth dorsal in *Diplodocus*).

Because work is still in progress, (DANTAS et al., in prep.), it is too early to safely establish the relationships of *Lourinhasaurus* n. gen. within existing families of sauropods.

Species composition: The taxon *Lourinhasaurus* n. gen. includes, to date, a single species: *Lourinhasaurus alenquerensis* (LAPPARENT & ZBYSZEWSKI, 1957) [= *Apatosaurus alenquerensis*].

Distribution: The taxon *Lourinhasaurus* n. gen. is, to date, known only from the Upper Jurassic (Upper Kimmeridgian-Lower Tithonian) of the Bacia Lusitânica, Portugal.

Lourinhasaurus alenquerensis (LAPPARENT & ZBYSZEWSKI, 1957)

Apatosaurus alenquerensis LAPPARENT & ZBYSZEWSKI, 1957: 33.

?*Camarasaurus alenquerensis* (LAPPARENT & ZBYSZEWSKI, 1957) - MCINTOSH, 1990, pp. 91, 349, 386.

Holotype: Geological Museum of the Geological and Mining Institute (formerly the Geological Services of Portugal); collection from the bed of Moinho do Carmo, Alenquer, Portugal; Upper Jurassic. Specimen constitutes 26 vertebrae (mostly dorsals; but also sacral, some cervical and a few anterior caudal vertebrae), 24 ribs (two cervical, the remaining ones thoracic), practically complete pectoral girdle (scapulae and associated coracoids), a significant part of the pelvic girdle (the left ilium, both ischia, and both pubes), remains of the forelimbs (both humeri, right radius and ulna, bones of the left carpus, plus part of metacarpal III and a phalanx of the second finger of the left forelimb) and of the hindlimbs (both femora, the left tibia, fibula, astragalus, and part of the calcaneum) fide LAPPARENT & ZBYSZEWSKI (1957).

Referred Material: Part of a skeleton composed of nine vertebral neural spines (their respective vertebral bodies destroyed by erosion), 12 complete vertebrae corresponding to the dorsal and posterior cervical area, 12 ribs (some of them complete) from both sides of the skeleton, some appendicular and girdle material a (very incomplete and badly conserved), several fragments of uncertain bones, an isolated tooth (?) and about a hundred gastroliths (DANTAS et al., 1992; DANTAS et al., 1998). Some of the osteological material has been deformed: the vertebrae are lightly stretched obliquely. Material originating from the Praia de Porto Dinheiro beds (Lourinhã, Portugal); Bacia Lusitânica; Lourinhã Formation; Upper Jurassic (Upper Kimmeridgian – Lower Tithonian).

Description: Postcranial skeleton (posterior cervical and dorsal vertebrae) –**upper part of the neural arch** (dorsal vertebrae) - neural spine medium to tall, projecting variably from 35 (in the first) to 46% (in the sixth) the total height of the vertebra. Neural spines deeply bifurcate in numbers 1, 2 and 3 and shallower (approximately 7 cm) in numbers 4, 5, 6 and 7. Neural spine vertical, forming an angle of about 90° with the long axis of the centrum; the spine is aligned with the posterior edge of the centrum in the posterior dorsal vertebrae, and a little more anteriorly inclined (in the previous half of the axial column) in the more anterior dorsals (in D1 and D2); vertebra D3 makes the transition between these two conditions. Lateral surfaces of ligament insertion features dorsoventrally high with angular and "convex" ventral ends, occupying more of half of the extent of the neural spine. Supradiapophyseal lamina very reduced and increasing slightly in size from D1 back. Suprapostzygapophyseal lamina medium to small. The postspinal lamina is the

laminae are flat. **Inferior part of the neural arch** (posterior cervicals and dorsals) - In the dorsal vertebrae, the inferior portion of the neural arch is extensive, low and covers almost the whole centrum. The cervical infradiapophyseal lamina, that links the diapophysis to the body of the vertebra, it is much larger in the posterior cervical vertebrae than in the dorsal ones; in the last two cervicals, it forms a low angle with the centrum (approximately 30°), while in the first dorsal this angle is larger (approximately 45°), connecting to the infraparapophyseal lamina described above (it appears in the first dorsal or possibly the last cervical and it is pronounced in the second dorsal; posteriorly, this lamina progressively increases in width, being visible in all dorsals); from here posteriorly, this angle retains the same approximate value (always between 35 and 45°) although it presents some progressive upward rotation, from the bottom upward (accompanying the gradual elevation of the parapophysis), because of this the infradiapophyseal lamina in the seventh dorsal is practically vertical. This rotation is reflected, for example, in the progressive increase of the angle that the posterior infradiapophyseal lamina makes with the longitudinal axis of the vertebral bodies (from 45° in the first to 90° in the seventh) or in the gradual increase in the angle that the infraparapophyseal lamina makes with the longitudinal axis of the vertebral bodies (from approximately 15° in the first to 45 to 50° in the seventh). The angle formed between the posterior infradiapophyseal and infraparapophyseal laminae (conjoined close to the base of the neural arch) retain a relatively constant angle (35-45°), in the dorsal vertebrae, plus the posterior infradiapophyseal lamina is present in the posterior cervicals and dorsals and retain the same longitude from dorsal 1 to 7, plus the constant presence of the diapostzygapophyseal lamina and respective fossa formed by its posterior edge, from vertebra to vertebra, are some of the several examples of the constancy of characters observed on the lateral surface from dorsals 1 through 7. A bifurcate secondary articular process (= accessory articulation) originates in the inferior and lateral area to the neural arch and "supports" the lateral expansion of the hyosphene; the same process fits into the prezygapophysis of the following vertebra; this feature is very important because it is very derived. The angle between the infraparapophyseal lamina and the long axis of the centrum is incipient in the first dorsal (approximately 15°) increasing progressively posteriorly, until it attains very large values (45 to 50° in the seventh). The infrapadiapophyseal lamina initially appears in the first dorsal, where it is very small, and increases progressively in extent through more posterior dorsals; in the seventh, for instance, it is very developed. The parapophysis is large in the first dorsal (to the third) then, abruptly, it decreases sharply starting from the fourth (inclusive) and in the other more posterior dorsals; the position of the parapophysis changes slightly from vertebra to vertebra. **Vertebral centra** (dorsal vertebrae) - the height of the centra of the dorsals, compared to the total height of the vertebrae, varies and decreases from 35 to about 24% from dorsal 1 to 7. From vertebra to vertebra, the "most abrupt change" in values in the studied vertebrae is seen from the fifth (ratio of 31%) to the sixth (ratio of only 24%). Opisthocoely present through the eighth and even more posterior vertebrae (it is also present in the posterior cervicals). The pleurocoel is of small to average dimensions (despite that, it increases in size, at least, from dorsal 1 to 5), elliptical, at times walled in (in the cases of dorsals 4 and 5) and it is closer to the anterior end to articulate with that of the posterior edge of the preceding centrum; concomitantly, it moves from the middle to the upper part of the centrum. On the ventral face small longitudinal carinae (= keels) are observed in the anterior dorsal vertebrae (1, 2 and 3); these carinae increase substantially in size in the posterior cervicals; regardless, the ventral surface of the centrum is flat in the fifth and subsequent vertebrae, while the fourth exhibits a transitional condition between the preceding and following conditions.

Comparisons and Discussion: The specimen of *L. alenquerensis* from Praia de Porto Dinheiro closely resembles relationship material identified as *Apatosaurus alenquerensis* or *?Camarasaurus alenquerensis*, particularly in the centra of the posterior cervical and dorsal vertebrae and with the remains of the neural arches from the beds of Moinho do Carmo, close to Alenquer.

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BIBLIOGRAPHY

- DANTAS, P. (1990) - Dinossáurios de Portugal. *Gaia*, 2: pp. 17-26.
- DANTAS, P.; FREITAS, C.; AZEVEDO, T.; GALOPIM DE CARVALHO, A.M.; SANTOS, D.; ORTEGA COLOMA, F.J.; SANTOS, V.F. DOS; SANZ, J.L.; SILVA, C.M. DA & CACHÃO, M. (1998) - Estudo dos gastrólitos do dinossáurio *Lourinhasaurus* do Jurássico superior português. *V Congresso Nacional Geologia*, Lisboa (neste volume).
- DANTAS, P.; FREITAS, C.; AZEVEDO, T.; SANZ, J.L.; GALOPIM de CARVALHO, A.M.; SANTOS, D. & SANTOS, V. (1993) - Sauropod Gastroliths study from Upper Jurassic of Lourinhã region (Western

- Portugal). *Resumo Comunic. "Premier Congrès Européen de Paléontologie"*, Lyon, p. 34.
- DANTAS, P.; SANZ, J.L. & GALOPIM de CARVALHO, A.M. (1992) - Dinossáurio da Praia de Porto Dinheiro (dados preliminares). *Gaia*, 5: pp. 31-35.
- DANTAS, P.; SANZ, J.L.; SILVA, C.M. da; ORTEGA COLOMA, F.J.; SANTOS, V.F. dos & CACHÃO, M. (em prepar.) - *Lourínhasaurus*, a new sauropod genus from the Upper Jurassic of Portugal.
- GILMORE, C. W. (1932) - On a newly mounted skeleton of *Diplodocus* in the United States National Museum. *Proc. U.S. Natl. Mus.*, 81, 21p.
- HATCHER, J.B. (1901) - *Diplodocus* (MARSH): Its osteology, taxonomy, and probable habits, with a restoration of the skeleton. *Mem. Carnegie Mus.*, 1, 63p.
- JANENSCH, W. (1929) - Wie Wirbelsaule der Gattung *Dicraeosaurus*. *Palaeontographica* (Suppl. 7), 2, pp. 39-133.
- JANENSCH, W. (1950-a) - Die Wirbelsaule von *Brachiosaurus brancai*. *Palaeontographica* (Suppl. 7), 3, pp. 27-93.
- JANENSCH, W. (1950-b) - Die Skelettekonstruktion von *Brachiosaurus brancai*. *Palaeontographica* (Suppl. 7), 3, pp. 97-103.
- LAPPARENT, A.F. & ZBYSZEWSKI, G. (1957) - Les Dinosauriens du Portugal. *Mem. Serv. Geol. de Portugal*, Lisboa (N.S.), 2, 63p.
- McINTOSH, J.S. (1990) - Sauropoda. In WEISHAMPEL, DODSON & OSMÓLSKA (eds.): *The Dinosauria*. Univ. Calif. Press, Berkeley, Los Angeles, Oxford, pp. 345-401.
- OSBORN, H.F. & MOOK, C.C. (1919) - *Camarasaurus*, *Amphicoelias*, and other sauropods of Cope. *Bull. of the Geolog. Society of America.*, 30, pp. 379-388.
- OSBORN, H.F. & MOOK, C.C. (1921) - *Camarasaurus*, *Amphicoelias*, and other sauropods of Cope. *Mem. Am. Mus. Nat. Hist.* (N.S.), 3, pp. 247-287.
- RIGGS, E.S. (1904) - Structure and relationships of opisthocoelian dinosaurs. Pt. II. Brachiosauridae. *Publ. Field. Columbian Mus. Geol.*, 2, pp. 229-248.
- SALGADO, L. & BONAPARTE, J.F. (1991) - Un nuevo sauropodo dicraeosauridae, *Amargasaurus cazau* gen. et sp. nov., de la formacion La Amarga, Neocomiano de la Provincia del Neuquen, Argentina. *Ameghiniana*, 28 (3-4), Buenos Aires, pp.333-346.
- SAUVAGE, H.E. (1897-98) - Vertébrés fossiles du Portugal. Contributions à l'étude des Poissons et des Reptiles du Jurassique et du Crétacique. *Direct. Trav. Geol. Portugal*, Lisboa, 29, 58p.