ISSN 0524-9511

REVISTA
DEL
MUSEO ARGENTINO DE CIENCIAS NATURALES "BERNARDINO RIVADAVIA"
E
INSTITUTO NACIONAL DE INVESTIGACIONES DE LAS CIENCIAS NATURALES

Paleontología **Tomo V, Nº 2**

A NEW DIPLODOCID, *DINHEIROSAURUS LOURINHANENSIS GEN. ET SP. NOV,* FROM THE LATE JURASSIC BEDS OF PORTUGAL

J.F. BONAPARTE* and O. MATEUS**

INTRODUCTION

The recent discovery of an articulated series of cervical and dorsal vertebrae, ribs, and fragmentary appendicular bones of a Late Jurassic sauropod on the coast of Portugal near Lourinhã (Dantas *et al.,* 1992), gives us the opportunity to know more on the history of this successful group of dinosaurs which roamed the Jurassic isles of the present Iberian Peninsula, in isolation from North America, Europe and Africa (Ziegler, 1988; Schudack and Schudack, 1989).

As suggested by Lillegraven and Krusat (1991) probably these islands made the scenario for differential evolution of land vertebrates in the Late Jurassic, as the genetic interchange with faunal assemblages of other continents was interrupted, eventually during several million of years.

The paleontological richness of the continental Middle and Late Jurassic beds of Portugal became well appreciated after the pioneering work of Dr. G. Zbyszewski of the Geological Survey of Lisboa, who made large collections of sauropods remains (Lapparent and Zbyszewski, 1957). In addition, the incredible work and collections made by the German paleontologists Drs. Henkel, Kuhne, Krusat, and Krebs, from the Freie Universität, Berlin, at the Guimarota coal mine, and at Porto "Pinheiro", confirmed the outstanding importance of the Late Jurassic of Portugal. More recently, the several discoveries of numerous footprints (Santos *et al.,* 1992; Santos *et al.,* 1994; Lockley *et al.,* 1994), as well as of hundreds of theropod eggs, many of them with embryos (Mateus *et al.,* 1997), and the recent discovery of an incomplete skull and jaws of a large Late Jurassic allosaurid

*Museo Argentino de Ciencias Naturales- Avda Angel Gallardo 470 - 1405 Buenos Aires Argentina.

**GEAL. Museu da Lourinhã and Departamento de Ciencias da Terra – Faculdade de Ciencias e Tecnologia - Universidade de Lisboa Monte da Caparica - Portugal. Email: omateus@mail.telepac.pt

(Mateus, in press), demonstrate that Portugal is one of the most productive and significant Middle and Late Jurassic regions of Europe. This information is critical for the understanding of the faunal relationships between the Northern continents themselves and of these continents with the isolated lands of the Iberian islands. The study of this new diplodocid is mostly based on vertebral anatomy, a source of information considered by the senior author as of great importance to recognize relationships within the Sauropoda (Bonaparte, 1986). At the same time this study attempts to gain some information on the distinct characters, developed by the group of diplodocids which were isolated in Iberia after the marine transgression which covered a great portion of it in the Late Jurassic (Ziegler, 1988; Schudack and Schudack, 1989).

The present study results from an agreement between the Museu da Lourinhã and the Museo Argentino de Ciencias Naturales, of Buenos Aires, in order to study this exceptional specimen collected in 1987-1990.

HISTORY OF THE DISCOVERY AND ANTECEDENTS

The specimen was discovered in 1987 by Mr. Carlos Anunciação, an assistant and friend of the Museu da Lourinhã, and excavated from 1987 to 1992. The persons and institutions cooperating in the job were: from the Museu da Lourinhã, C. Aunciação, H. Mateus, I. Mateus, 0. Mateus, and V. Ribeiro; from the Museu de História Natural da Universidade de Lisboa, P. Dantas, C. Marquez da Silva, M. Cachão, and V. Santos, and from the Universidade de Salamanca, F. Ortega and S. Tudanca. The discovery was preliminarily announced by Dantas *et al.* (1992).

The remains were found near the top of the coastal cliff, and for the excavation a bulldozer and tilt hammer were used. Two big blocks were prepared with poliuretane, provided with a strong supporting basis, and removed up with the help of a crane.

In 1993, the senior author and Mr. P. Dantas began the study of the specimen but it was not finished. In a recent paper by Dantas *et al.* (1998) they have interpreted that *Apatosaurus alenquerensis* Lapparent & Zbyszewski 1957 does not correspond with the genus *Apatosaurus* Marsh (1877), nor with the genus *Camarasaurus* Cope (1877) as was interpreted by McIntosh (1990) and Wilson and Sereno (1998), but to a new genus, as it was tentatively interpreted by McIntosh *et al.* (1996). As a result, Dantas *et al.* (1998) proposed the new genus *Lourinhasaurus* and the combination *Lourinhasaurus alenquerensis* (Lapparent and Zbyszewski 1957). The holotype, as indicated by Dantas *et al.,* is the same for *"Apatosaurus alenquerensis"* described and figured by Lapparent and Zbyszewski (1957 pp. 33-40, figs. 10, 11 and 12, and plates XV figs. 39, 41; XVI fig. 43; XVII fig. 45; XVIII fig. 47; XIX figs. 51, 52; XX figs. 56, 57, 58; XXI figs. 68, 69, 70; XXV fig. 89; XXVII fig. 99; XXVIII fig. 105 A; XXIX figs. 116, 117; XXXV figs. 149, 153).

We consider that the proposal of the genus *Lourinhasaurus* is correct and that the species *Lourinhasaurus alenquerensis* is also correct as it is based on the holotype designated by Lapparent and Zbyszewski for *'Apatosaurus alenquerensis"*. But, we consider that the assignation of the incomplete skeleton from Porto Dinheiro deposited at the Museu da Lourinhã, made of a sequence of cervical and dorsal vertebrae, very fragmentary appendicular bones and near a hundred of gastrolites discovered in closed association with the vertebrae, to the genus and species *Lourinhasaurus alenquerensis* is incorrect. Simply there is no anatomical evidence for such a procedure because the taxonomical identification of both specimens is impossible. In the holotype no cervical or dorsal neural arches which would be fundamental for identification are preserved, while in the referred specimen there are no appendicular, pelvic or pectoral girdle bones to compare with those of the holotype.

The sauropod specimen deposited in the paleontological collection of the Museu da Lourinhã, made of significant cervical and dorsal vertebrae, is here described and figured as a new genus and species of the Diplodocidae. We understand that only with more complete discoveries to be made in the future, we shall be in a position to interpret the relationships or eventual synonymy of it with the incomplete remains of any of the known Late Jurassic sauropods from Portugal.

SYSTEMATIC PALEONTOLOGY

Sauropodomorpha Huene 1932
Sauropoda Marsh 1878
Diplodocidae Marsh 1884

Dinheirosaurus *gen. nov.*

Derivation of name. From Porto Dinheiro, the locality where the holotype was collected.
Type species. ***Dinheirosaurus lourinhanensis*** *sp. nov.*

Dinheirosaurus lourinhanensis *gen. et sp. nov.*

Derivation of name. From Lourinhã, name of the Municipality where the holotype was found.
Holotype. Museu da Lourinhã, Paleontology, ML414.
Material. The holotype is made up of two incomplete cervical and nine rather complete, articulated dorsal vertebrae, seven fragmented centrae, some incomplete neural arches, twelve dorsal ribs, and fragmentary appendicular bones.
Locality. Porto Dinheiro, on the half height of the coastal cliff, near Lourinhã, Portugal.
Horizon. Upper section of the Camadas de Alcobaca Formation, (= "Formação da Lourinhã"), (Fig. 1), Late Kimmeridgian.
Age. The Camadas de Alcobaça Formation bearing *Dinheirosaurus*

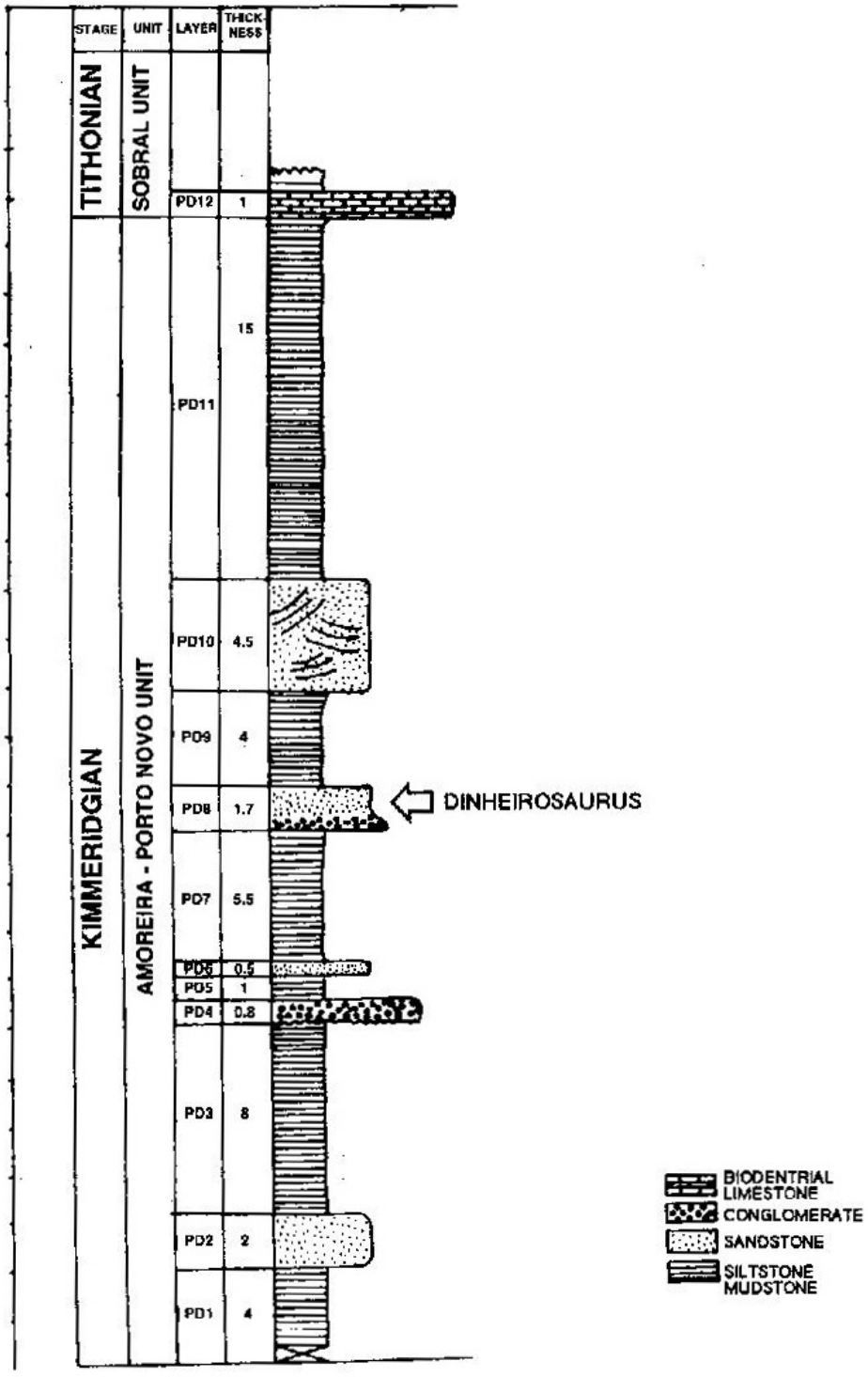

Fig. 1- Stratigraphical column of the area of Porto Dinheiro, Municipality of Lourinhã, with indication of the level with the Diplodocid sauropod *Dinheirosaurus lourinhanensis* gen. et sp. nov.

lourinhanensis gen. et sp. nov., outcropping around Porto Dinheiro, has been dated as late Tithonian to early Berriasian on palynological data by Mohr (1989). Helmdach (1973-74) based on brackish-water ostracods dated this unit as of Late Kimmeridgian age. This chronological interpretation was confirmed by Manupella (1996).

Diagnosis. Posterior cervical and dorsal vertebrae of the *Diplodocus* type, with bifurcated neural spines, but with only one well defined infraparapophysial lamina present from dorsal 4 backwards. In mid and posterior dorsals, the cited lamina is obliquely directed from the parapophysis to the ventroposterior corner of the neural arch. A complex structure derived from the hyposphene makes an accessory articulation, exposed in lateral view. Lower section of the neural arch of the mid and posterior dorsal vertebrae dorsoventrally shorter than in *Diplodocus.*

Description

Cervical vertebrae

Cervical vertebrae are represented only by two incomplete vertebrae. We assume that there were possibly 15 cervical vertebrae. In this case cervical 13 and 14 are preserved, while cervical 15 is lacking , because it was lost during excavation.

Cervical 13. It is exposed in lateroventral view, with only partial preparation. Its centrum measures 71 cm in length. The parapophysis, diapophysis, and neural spine are broken, so there is limited information available. The lateral depression of the centrum is deep, with similar features to those of cervical 14 (Fig. 2).

Cervical 14 (Fig. 2). It is reasonably complete but with a hard break separating the dorsal section of the neural arch from the line of the postzygapophysial-diapophysial lamina, and some distortion affecting the neural arch. The centrum is 63 cm long, exposed in ventral and lateral views. Ventrally it is transversally concave, with the parapophysis anteroposteriorly wide, laminar, and ventrolaterally directed. In the posterior section, a small axial keel is present. Posterior to the parapophysis, in lateral view, runs a narrow depression, well defined by sharp edges, forming an angle between the ventral and lateral views of the centrum. The lateral concavity of the centrum is fully exposed because the diapophysial lamina is not preserved. A rod-like structure runs the whole length of the lateral depression along its lower section. Such a structure is obliquely elevated on its anterior and posterior sections, forming an anterior and posterior fenestra. A much larger fenestra is present above the rod-like structure and below a large lamina present in the upper section of the centrum. This lamina is the largest structure of the centrum, present from near the posterior border up to the triangular area of the junction of the infradiapophysial laminae, in the lower section of the neural arch. The condyle of the centrum is rather large.

The neural arch, although incompletely preserved, exhibits well defined features. The postzygapophysis and the lamina bearing it are complete. The postzygapophysis is laterally concave, medially wider than dorsolaterally. An infrapostzygapophysial lamina is present. The prezygapophysial process is

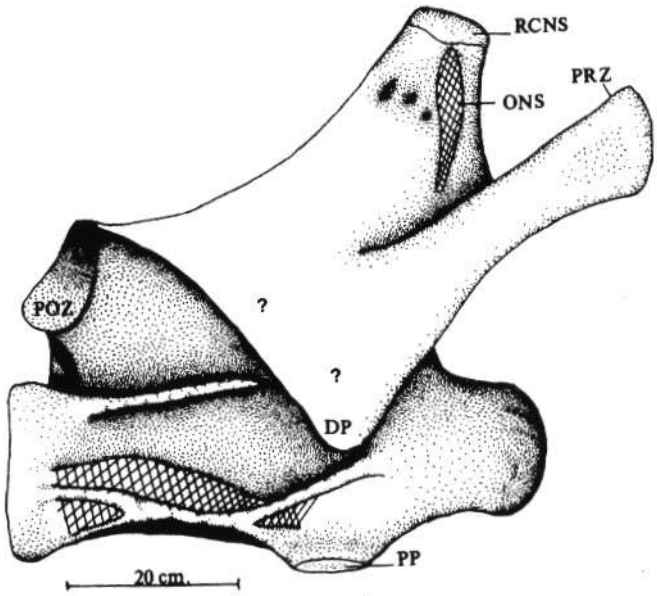

Fig. 2– *Dinheirosaurus lourinhanensis gen. et sp. nov.*, Reconstruction of the cervical 14th in lateral view. The original is partially distorted and some breaks are present. DP- diapophysis; ONS- fenestra of the neural spine; POZ- postzygapophysis; PP- parapophysis; PRZ- prezygapophysis; RCNS- rugose cup of the neural spine.

elongate, with an expanded distal end for the prezygapophysis, and laterally placed to the anterior section of the neural spine. According to the only preserved fragment of the cervical 15 which corresponds to the anterior portion of the prezygapophysial process, possibly cervical 14 had a similar morphology, with a lateral depression near its end, and a dorsal and a ventral thickening. The prezygapophysial process has some breaks and it is long, surpassing the anterior border of the centrum.

The neural spine is dorsoventrally rather short, with a near vertical anterior side, much higher than the posterior side. The top of the neural spine is rather massive. On the lateral side of the neural spine a deep furrow dorsoventrally projected is present. Posterior to this furrow three small depressions are located.

Comparisons of the cervicals

The comparison of this vertebrae with the posterior cervicals of *Diplodocus* shows good similarities: a) similar proportions in anteroposterior and dorsoventral length; b) degree of complexity on the lateral cavity of the centrum; c) neural spine in line or forward than the parapophysis; d) high suprapostzygapophysial lamina; e) massive cup on top of the neural spine; f) dorsoventral furrow on the lateral side of the neural spine; and g) large lateral exposure of the lamina connecting the postzygapophysis with the neural

spine. The association of these characters is present only in the posterior cervicals of *Diplodocus* and *Dinheirosaurus*, and not in other sauropods.

The above comparison of cervical 14 of *Dinheirosaurus* suggests that its morphology is basically of the *Diplodocus* type, with some differences in the system of ridges of the lateral view of the neural arch. The two ridges going down from the top of the cup of the neural spine of cervicals 13 and 14 of *Diplodocus carnegii* (Hatcher, 1901, plate III) are not present in *Dinheirosaurus lourinhanensis*. The long and elevated prezygapophyseal process of cervical 14 of *D. carnegii* is basically of the same morphology as in *D. lourinhanensis*, but slender in the latter.

The morphology of the centrum of cervical 14 of *D. lourinhanensis* is also like in *D. carnegii*, with a very similar system of ridges and cavities. However, the ventral keel is more pronounced in the American species (Hatcher 1901, plate III), and the postero-ventral ridge of the centrum of *D. lourinhanensis* is distally bifurcated, while it is not in *D. carnegii*.

Obviously the information from the posterior cervicals here described afford good evidences to interpret that *Diplodocus* and *Dinheirosaurus* are closely related genera of the family Diplodocidae, but with differential development of serevral characters in the neural arch and in the centrum. Shared derived characters present in the posterior cervical vertebrae of both genera are the following: a) elongated and low centra provided with two or more lateral fenestrae bordered by ridges; b) long prezygapophyseal process surpassing the condyle of the centrum, with a well developed prezygapophysial-diapophysial lamina; c) top of the neural spine with a rugose cup, and a ventral fenestra below it.

Dorsal vertebrae

A sequence of articulated dorsals are preserved, from dorsal 1 through dorsal 7. Most of them are complete, but with some distortion from lateroventral forces. The general aspect of them shows they are tall, provided with a tall, divided, and vertical neural spine, placed on line with the middle and posterior section of the neural arch.

Dorsal 1. This vertebra is tentatively considered the first dorsal, but it may be the last cervical. In *Diplodocus* the first and second dorsals are of the type of the last cervicals, with low and elongate centra. So, in incomplete series like that of *Dinheirosaurus* it is not easy to identify the first dorsal. The possible first dorsal of this genus is incomplete, with the anterior section of the centrum damaged. The centrum measures 58 cm long, and the estimated height of the vertebra is approximately 40 cm. The ventral side of the centrum is convex with a median and a lateral crest on each side, all them of modest relief.

The lateral view of the first dorsal is poorly preserved, lacking most of the diapophysial lamina. However, there are indications that its morphology is similar, in general terms, to that of the posterior cervical described above. The neural spine is of the cervical model, bearing a dorsoventral furrow, low and axially long. It is located within the posterior half of the vertebra.

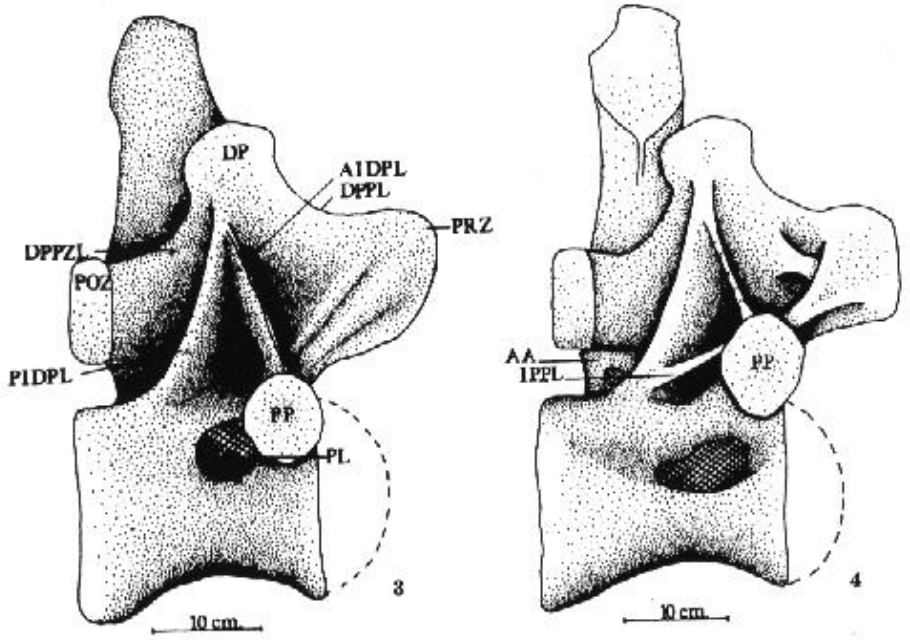

Fig. 3-4. Dinheirosaurus lourinhanensis *gen. et sp. nov.*. Reconstruction of the dorsal 3rd in lateral view. The original is complete but with some distortion. Abbrev. As in last figure and AIDPL- infradiapophysial lamina; DPPL- diapophysial-prezygapophysial lamina; DPPZL- diapophysial-postzygapophysial lamina; PIDPL- posterior infradiapophysial lamina; PL-pleurocoel. **4.** Reconstruction of the dorsal 4th in lateral view. The original is complete but with some distortion. Abbrev. As in previous figures and: AA- accessory articulation; IPPL- infraparapophysial lamina.

Dorsal 2. It is shorter than dorsal 1, with only 32 cm in length. Dorsoventrally measures approximately 49 cm. The centrum has a small pleurocoel on the posterior half of it. The transverse process is long, lateroanteriorly projected. Prezygapophysial process, as preserved, surpasses the anterior border of the centrum. The neural spine is in line with the anterior border of the centrum, and bears a well defined, rugoze cup. Below it is present a vertical furrow which is also present in previous vertebrae.

Dorsal 3 (Fig. 3). This vertebra is rather complete but with strong ventrolateral distortion. The centrum is 35 cm long, and the total height of the vertebra is approximately 51 cm. The opisthocoelian centrum has a small pleurocoel within the anterior half of it. Parapophysis is on the upper section of the centrum. The diapophysis is large, with well defined anterior and posterior infradiapophysial laminae. The prezygapophysis surpasses the anterior border of the centrum. It is lateromedially large (seen only in lateroventral view), supported by a structure with three dorsoventral ridges. The neural spine is narrow and high in this and following dorsals. The cervical type of the neural spine is present only in dorsals 1 and 2.

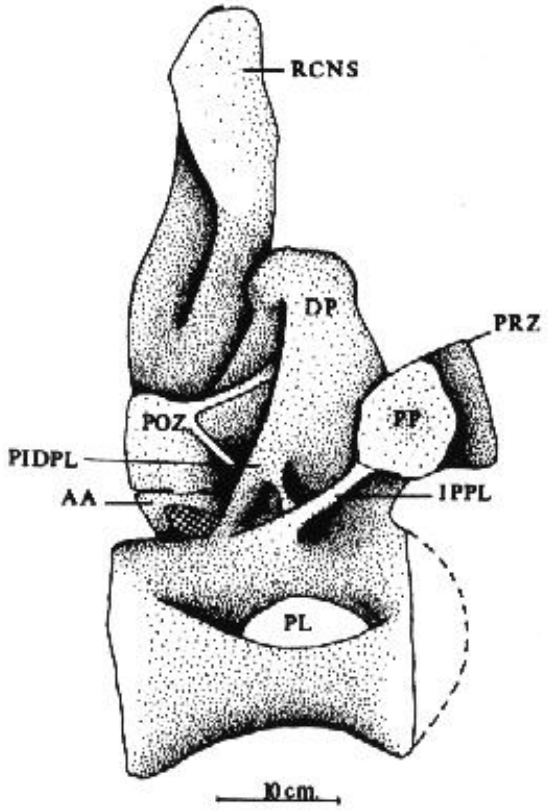

Fig. 5. *Dinheirosaurus lourinhanensis gen. et sp. nov*. Reconstruction of the dorsal 5th in lateral view. The original is complete but with some distortion. Abbrev. as in previous figures.

Dorsal 4 (Fig. 4). This vertebra is higher than previous dorsals. The centrum is approximately 27 cm long, and the estimated total height is 58 cm. Probably it is opisthocoelian, but direct observation is not possible. The pleurocoel is bigger than in dorsal 3 ad is nearer the anterior border of the centra. Diapophysis is in a more vertical position than in previous vertebrae, approximately in line with the pleurocoel. Parapophysis is above the dorsal border of the centrum. In this vertebra it is the first appearance of the posterior parapophysial lamina, a derived character which characterizes the following presacrals of *Dinheirosaurus*. In this vertebra it encloses ventrally a subtriangular fossa.

The two infradiapophysial laminae, whose presence is a primitive character (Bonaparte, in press), are well defined. The posterior one is stronger than the anterior. The prezygapophysis is anteriorly and lateromedially large, supported by a lamina with two strong ridges which converge to the anterodorsal side of the parapophysis.

Dorsal 5. The length of the centrum is 28 cm aprox., and the total height of the vertebra is aproximately 68 cm. The pleurocoel is eye-like in

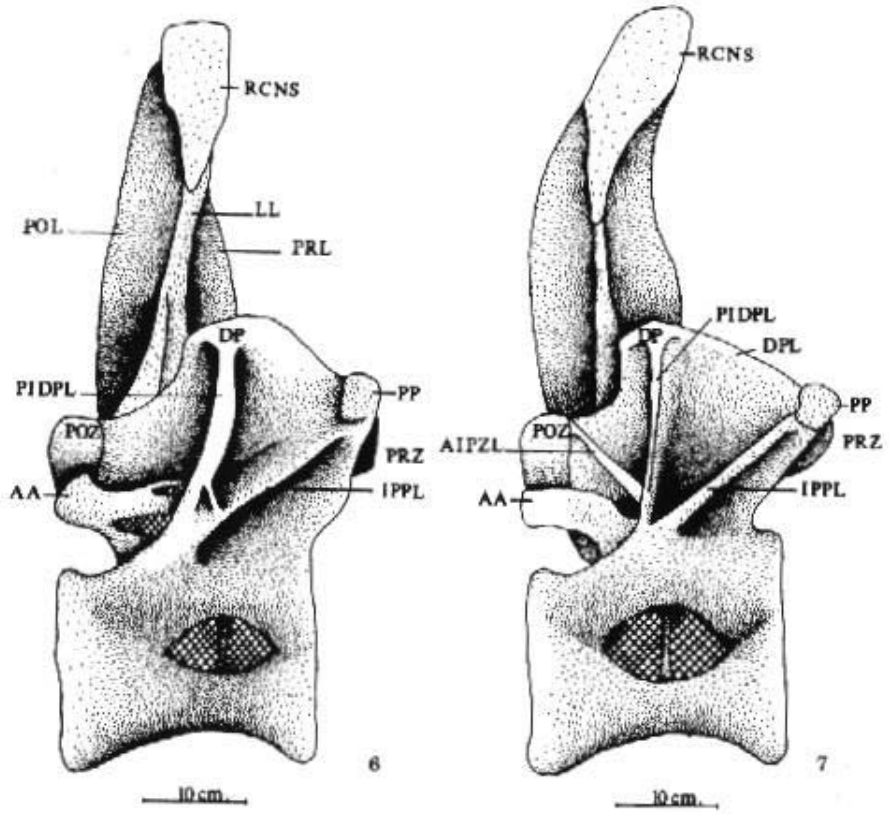

Fig. 6-7- *Dinheirosaurus lourinhanensis*, *gen. et sp. nov.* **6.** Reconstruction of the dorsal 6th in lateral view. The original is complete but with some distortion. Abbrev. as in the previous figures and: LL- lateral lamina; POL- postspinal lamina; PRL- prespinal lamina. **7.** Reconstruction of the dorsal 7th in lateral view. The original is complete but with some distortion. Abbrev. as in previous figures and: DPL- diapophysial lamina.

shape, located within an anteropopsteriorly depressed area. The infraparapophysial lamina is longer than in the fourth dorsal. The anterior infradiapophysial lamina is almost absent, representing a derived character (Bonaparte, in press).

Two strong ridges connect the posterior infradiapophysial lamina with the lamina running from the diapophysis to the postzygapophysis. Another ridge connects the posterior infradiapophysial lamina with the posterior parapophysial lamina. In this vertebrae a derived structure appears: an accessory articulation which originates on the ventrolateral area of the hyposphene and runs anteriorly to the posterior side of the infradiapophysial lamina (Fig. 5, AA). This structure well defined in dorsals 5 through 9, and articulates dorsally with the ventromedial side of the prezygapophysis, hypantrum, of the next following vertebra.

Dorsal 6 (Fig. 6). The centrum measures 29 cm in length, and the total height of the vertebra is about 75 cm. The pleurocoel is larger than in the previous vertebra, located in a defined depression. A vertical rod-like bone divides the pleurocoel in two. The diapophysial lamina is large, connecting both pre and postzygapophysis.

Two derived features are recognized in this vertebra: a) the infraparapophysial lamina running ventromedially and posteriorly, in direction to the posterior upper corner of the centrum and b) the presence of an accessory articulation derived from the hyposphene and connected to the posterior side of the infradiapophysial lamina. The bifurcated neural spine has a rugose cup, a well defined posterior lamina, a modest anterior lamina, and a lateral lamina which is ventrally bifurcated.

Dorsal 7 (Fig. 7). The centrum shows some anteroposterior deformation due to compression. Its estimated length is 25 cm. The total height of this vertebra is approximately 76 cm. The centrum is relatively low, provided with a large pleurocoel divided by a dorsoventral rod-like bone. This pleurocoel is the biggest in the dorsal series, decreasing backwards in size. In the dorsal 8 the pleurocoel is less than half the size of that of dorsal 7. In the neural arch the anterior infrapostzygapophysial lamina is present which connects to the lower section of the infradiapophysial lamina. It is a rather strong structure not observed in previous dorsal vertebrae, but it is present in dorsals 7, 8 and 9. The infraparapophysial lamina appears to be stronger and more developed than in dorsal 6.

The structure of the accessory articulation derived from the hyposphene does not bear the two fenestra present in dorsal 6. It is in a more dorsal position and is projected more backwardly.

Dorsals 8 and 9. These two vertebrae are basically of the same morphology as dorsal 7, with only a few minor changes in their morphology. The accessory articulation developed from the hyposphene, persists in these vertebrae, but in a more dorsal position, possibly as a result of the more dorsal placement of the zygapophyses. The infraparapophysial lamina is present in these posterior dorsals running obliquely posteroventrally.

Comparison of the dorsals

An anterior dorsal vertebra of the cervical type, with an elongated centrum, a proportionally low and wide neural spine, and vertically directed neural spines are characteristic of the anterior dorsal vertebrae of *Diplodocus* (Hatcher, 1901) and *Haplocauthosaurus* (Hatcher, 1904) (Fig. 8). In other sauropods such as *Camarasaurus* (Osborn and Mook, 1921), *Dicraeosaurus* (Janensch, 1929) and *Apatosaurus* (Gilmore, 1936), the anterior dorsals are higher and shorter.

The general proportions of the central and posterior dorsals of *Dinheirosaurus* are comparable with those of *Diplodocus.* The resemblances are extensive to the morphology and structure of the neural spine, the basic design of the system of laminae, and the characters of the centra and pleurocoels. Unfortunately, in the present state of preparation of these vertebrae it is not possible to be sure about the posterior distribution of the

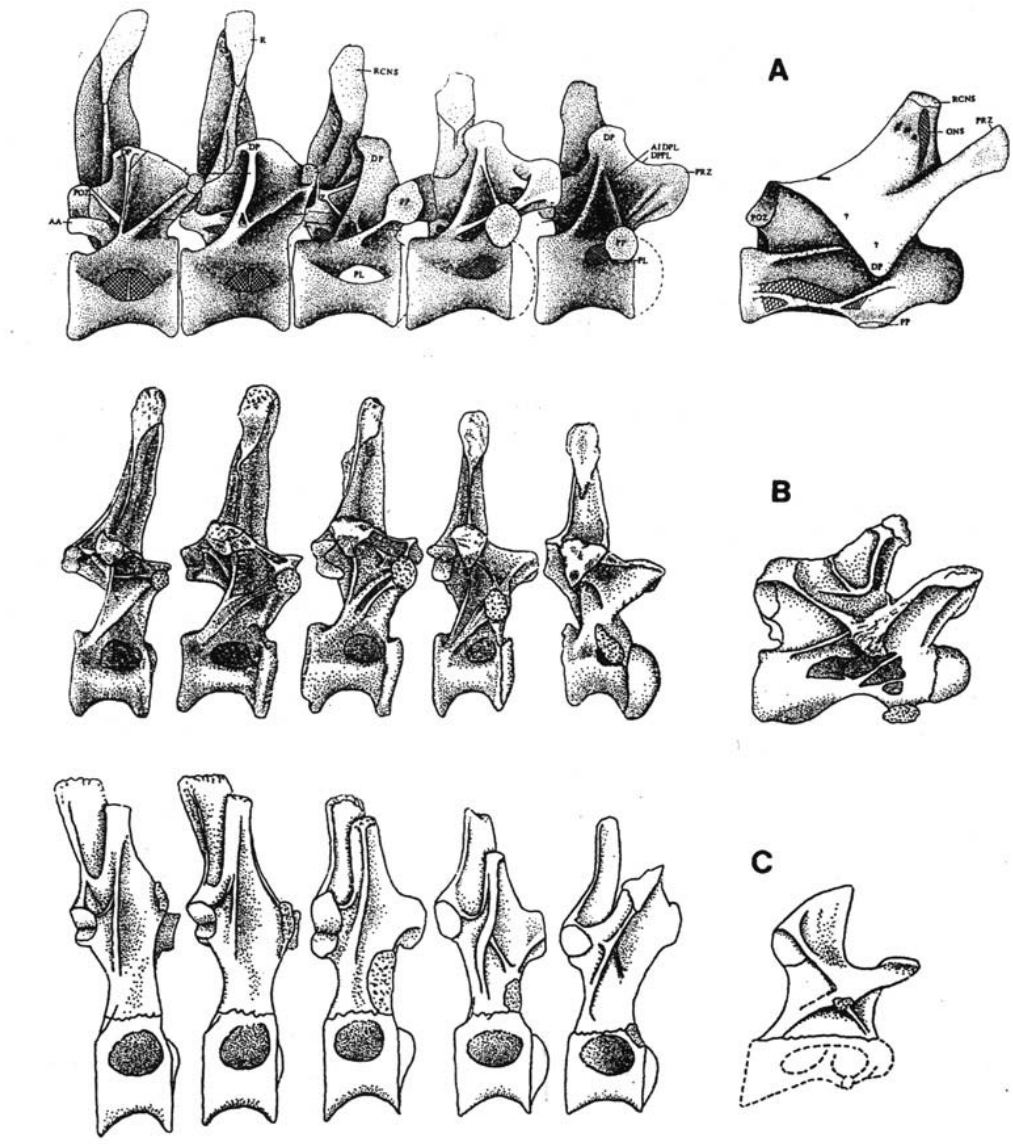

Fig. 8. A, *Dinheirosaurus lourinhanensis*. Cervical 14th (at right end), and the sequence of dorsals 3rd to 7th, in right lateral view, for comparison with those of B, *Diplodocus carnegii*, and C, *Haplocanthosaurus utterbackii*, both from the Late Jurassic of North America. Note the similarities of the structure of the neural spine, the presence of the infraparapophysial lamina from the 4th dorsal backwards, and the morphology of the pleurocoels in *Dinheirosaurus* and *Diplodocus*, accompanied by a significant difference in the dorsoventral length of the lower section of the neural arch. B, redrawn from Hacther (1901); C, redrawn from Hatcher (1904). Not to scale.

opisthocoely. We infer, after observations in the union of some dorsals, that it may be more developed than in *Diplodocus.* Some derived characters included in the diagnosis suggest generic differences between *Diplodocus* and *Dinheirosaurus.* They are the following:

1) In *Dinheirosaurus* a well defined paired structure originated on the posteroventral area of the neural arch is present, making an accessory articulation between two vertebrae, derived from the hyposphene and contacting with the hypanthrum.
2) In *Dinheirosaurus* the lower section of the neural arch is dorsoventrally lower than in *Diplodocus.*

DISCUSSION

Two Late Jurassic sauropods are known in Portugal, the brachiosaurid *Brachiosaurus atalaiensis* and the camarasaurid *"Apatosaurus" alenquerensis,* both described by Lapparent and Zbyszewski (1957). McIntosh (1990) argued that some characters as the number of dorsals, the opisthocoelian condition of the last dorsals, the humero-femoral ratio, and the expanded distal end of the scapula, suggest that *'Apatosaurus" alenquerensis* is possibly *Camarasaurus,* although with a question mark. More recently, Wilson and Sereno (1998) considered Macintosh's interpretation is probably correct, assuming that the slender ischial shaft of *"Apatosaurus" alenquerensis* resembles that of *Camarasaurus.* Finally, Dantas *et al.* 1998 proposed a new genus, *Lourinhasaurus,* for the holotype of *"Apatosaurus" alenquerensis.*

The presacral vertebrae of *Dinheirosaurus* preclude any relationships with both *Camarasaurus* and *Apatosaurus* from North America (Osborn and Mook, 1921; Gilmore, 1936) because of the so different morphology of the presacral vertebrae.

Lourinhasaurus alenquerensis (Lapparent and Zbyszewski, 1957), is probably a valid genus and species, denying the suggestion by McIntosh (1990), and Wilson and Sereno (1998) that it may be *Camarasaurus.* However, it may be synonymous with the new taxon here described, a possibility that cannot be checked at present because there are no preserved neural arches in *Lourinhasaurus alenquerensis* or even in *Brachiosaurus atalaiensis* Lapparent and Zbyszewski (1957), and it must remain unresolved until new material is recovered and studied. Recently McIntosh *et al.* (1996) suggested that *"Apatosaurus"* alenquerensis might correspond to a new genus, which is confirmed by Dantas *et al.* 1998.

According to McIntosh (1990), Diplodocidae includes the genera *Diplodocus, Barosaurus, Apatosaurus, Amphicoelias, Supersaurus, Distrophaeus, Cetiosauriscus, Seismosaurus, Dicraeosaurus, Nemegtosaurus, Quaesitosaurus,* and *Rebbachisaurus.* Wilson and Sereno (1998) have included in the Diplodocidae only *Diplodocus, Barosaurus,* and *Apatosaurus.*

Our interpretation is that the Diplodocidae is made up by the genera

Diplodocus, Amphicoelias, Barosaurus, Cetiosauriscus, Distrophaeus, Supersaurus, Seismosaurus, and *Dinheirosaurus* gen. nov. *Apatosaurus* is not considered by the senior author as a Diplodocidae because of the strong differences in the cervical and dorsal vertebrae with *Diplodocus* and, in particular, the marked morphological differences involved in the cervico-dorsal transition (Bonaparte, 1996). Besides, the genus *Dicraeosaurus* (Janensch 1929) has been interpreted as Dicraeosauridae by Salgado and Bonaparte (1991); and *Rebbachisaurus* was interpreted as Rebbachisauridae (Bonaparte, 1997). *Nemegtosaurus* Nowinski (1971) and *Quaesitosaurus* Kurzanov and Bannikov (1983) are regarded as sauropods related to the Titanosauridae by Calvo (1994), Salgado and Calvo (1997), and Wilson and Sereno (1998). We interpret that *Dinheirosaurus* is a member of the Diplodocidae because of the general affinities with *Diplodocus* in the posterior cervical and dorsal vertebrae. However, some significant derived characters present in *Dinheirosaurus* suggest it is more specialized than *Diplodocus,* for example the accessory articulations present in dorsal 4 through 9 described above.

The biochron of the Diplodocidae may be from the Callovian through the Tithonian if *Cetiosauriscus* is considered a Diplodocid as proposed by Charig (1980) and McIntosh (1990). If not, the biochron is restricted to the Kimmeridgian-Tithonian, representing less than 10 million years.

The paleogeography of Portugal and most of the Iberian Peninsula (Ziegler, 1988; Schudack and Schudack, 1989) indicates that it was made up by several isles which were separated from continental Europe as well as from North America by marine barriers. As indicated by Lillegraven and Krusat (1991), the isolated condition of this region gave rise to endemisms within the continental vertebrates, in particular those groups with relatively rapid evolutionary changes, as we interpret were the sauropods.

Dinheirosaurus is probably an endemic genus of Portugal, with some characters more derived than in *Diplodocus,* presumably developed by effects of the geographic isolation. But, at the same time, with some more primitive characters, i.e. the reduced height of the neural arch below the transverse process. This primitive character suggests that *Dinheirosaurus lourinhanensis* is not derived from *Diplodocus carnegii* itself, but from a more primitive species. Equally, its morphology suggests that it may be a bit younger than *Diplodocus,* but this assumption is not confirmed by biostratigraphical studies made in recent years (Helmdach, 1973-74; Mohr, 1989; Manupella, 1996).

It seems clear that an apparent evolutionary divergence occurred between *Diplodocus* and *Dinheirosaurus,* eventually as the result of the geographic isolation of the American and Portuguese populations of Diplodocids through several millions of years.

Acknowledgements.

Thanks are due to the following institutions and persons: GEAL-Museu da Lourinhã Vasco Ribeiro, Horácio and Isabel Mateus); Museu de História Natural da Universidade de Lisboa (Dr. Pedro Dantas, Dr. Carlos Marques da Silva, Prof. Dr. Galopim de Carvalho, Dr. Vanda Santos and Dr. Mario Cachão); Universidad de Salamanca (Dr. Francisco Ortega and Dr. Santiago Tudanca); and Departamento de Ciencias da Terra da Faculdade de Ciências da Universidade Nova de Lisboa (Prof. Dr. Miguel Telles Antunes). Special thanks are given to the Camara Municipal da Lourinhã for several facilities to organize and develope this study. Our sincere thanks to two anonymous reviewers who made important suggestions to the first version of this manuscript.

Abstract

Presacral vertebrae of a new Diplodocidae from the Late Jurassic Amoreira-Porto Novo Formation of Lourinhã, Portugal are described and figured. *Dinheirosaurus lourinhanensis gen. et sp.* is diagnosed by well developed accessory articulations derived from the hyposphene, exposed in lateral view; and by the smaller dorsoventral length of the lower section of the neural arch. It is considered that the organization of the dorsal neural arch of *Dinheirosaurus* is more derived than in *Diplodocus,* except in the dorsoventral development of the lower portion of it, which is higher (more derived) in the latter. Possibly the isolated geography of Portugal in the Late Jurassic gave rise to the distinct characters of this new genus.

BIBLIOGRAPHY

Bonaparte, J. F., 1986. The early radiation and phylogenetic relationships of the Jurassic sauropod dinosaurs, based on vertebral anatomy. In: Padian, K., (Ed.) *The beginning* of *the age of dinosaurs,* pp. 247.258. Cambridge University Press.

Bonaparte, J.F., 1996. The presacral vertebra of *Apatosaurus* suggest a different family: Apatosauridae. *Dinofest International Symposium,* Wolberg, D.L. and Stump, E. (Eds.) *Program and Abstracts,* pp.30, Arizona State University.

Bonaparte, J. F., 1997. *Rayososaurus agrioclisis* Bonaparte 1995. *Ameghiniana, 34* (1):116. Resumenes.

Bonaparte, J.F., (in press) Notas sobre Ia evolución de las vertebras presacras en los Sauropodomorpha. *Ameghiniana 35.*

Calvo, J. 0., 1994. Jaw mechanics in sauropod dinosaurs. *GA!A,* 10: 183.193. Charig, A.J., 1980. A Diplodocid sauropod from the Lower Cretaceous of England. In: Jacobs, L. (Ed.) *Aspects of Vertebrate history,* pp. 231-244. Museum of Northern Arizona Press.

Charig, A. (1980). A diplodocid sauropod from the Lower Cretaceous of England. In: Jacobs, L. L. (ed.). *Aspects of Vertebrate History*. pp.231-244. Museum of Northern Arizona Press.

Dantas, P.M., Sanz, J.L., and Galopim de Carvalho, A.M., 1992. Dinossauro da Praia De Porto Dinheiro (dados preliminares). *GAIA,* 5:31-35.

Dantas, P.M., Sanz, J.L., Silva, C. M. Da, Ortega, F., Santos, V.F. Dos, and Cachão, M. 1998. *Lourinhasaurus nov. gen.* Novo dinossauro saurópode do Jurássico superior (Kimmeridgiano superior- Titoniano inferior) de Portugal. *Comunicações do Instituto Geológico e Mineiro,* 84 (1): 91-94. V Congresso

Gilmore, C. W., 1936. Osteology of *Apatosaurus,* with reference to specimens in the Carnegie Museum. *Memoirs of the Carnegie Museum,* 11 (4):
175-300.

Hatcher, J.B., 1901. *Diplodocus* Marsh its osteology, taxonomy, and probable habits, with a restoration of the skeleton. Memoirs of the Carnegie Museum 1: 1-63.

Hatcher, J.B., 1904. Osteology of *Haplocanthosaurus* with description of a new species, and remarks on the probable habits of the Sauropoda and the age and origin of the *Atlantosaurus* beds. Memoirs of the Carnegie Museum 2: 1-72.

Helmdach, F.-F., 1973-74. A contribution to the stratigraphical subdivision of non-Marine sediments of the Portuguese Upper Jurassic. *Cornunicações dos Serviços Geológicos de Portugal* 57:1-21.

Janensch, W., 1929. Die Wirbelsaule der Gattung *Dicraeosaurus.* Palaeontographica Suppl. 7, 2: 39-133.

Janensch, W., 1950. Die Wirbelsaule von *Brachiosaurus brancai. Palaeontographica* Suppl. 7, 3: 27-93.

Kurzanov, S.M. and Bennikov, A.F., 1983. (A new sauropod from the Upper Cretaceous of Mongolia). *Paleontological Journal* 1983: 91-97. (In Russian).

Lapparent, A.F. and Zbyszewski, G., 1957. Les dinosauriens du Portugal. *Mern. Serv. Geol. de Portugal,* 2: 1-63

Lillegraven, J.A. and Krusat, G., 1991. Cranio-mandibular anatomy of *Haldanodon expectatus* (Docodonta; Mammalia) from the Late Jurassic of Portugal and its implications to the evolution of mammalian characters. *Contributions to Geology,* University of Wyoming 28 (2): 39-138.

Lockley, M.G., Santos, V.F. dos, Meyer, C.A., and Hunt, A., 1994. Aspects of sauropod biology, (Eds.) *Revista de Geociências,* Museu Nacional de História Natural, 10:1-279.

Manupella, G., 1996. Carta Geológica de Portugal 1/50.000. Falha da Lourinhã. (Coord.), Instituto Geológico e Mineiro de Portugal.

Mateus, I., Mateus, H., Telles Antunes, M., Mateus, 0., Taquet, P., Ribeiro, V., and Manupella, G., 1997. Couveé, oeufs et embryons d'un Dinosaure Theropode
du Jurassique de Lourinhã (Portugal). *C.R. Academie Sciences Paris; Sciences de la terre et des planetes,* 325: 71-78.

Mateus, 0., (in *press).Lourinhanosaurus antunesi,* (Dinosauria; Theropoda) from Lourinhã (Portugal). *Memórias da Academia de Ciências de Lisboa.*

McIntosh, J.S., 1990. Sauropoda . In: Weishampell, D.B., Dodson, P., and Osmólska H., (Eds.) *The Dinosauria.* University of California Press, pp. 345-401

McIntosh, J.S., Miller, W.E., Stadtman, K.L., and Gillette, D.D., 1996. The osteology of *Camarasaurus lewisi* (Jensen, 1988). BYU Geology Studies 41: 73-115.

Mohr, B.A.R., 1989. New palynological information on the age and environment of Late Jurassic and Early Cretaceous vertebrate localities in the Iberian Peninsula (eastern Spain and Portugal). *Berliner Geowissenschaftliche Abhandlungen* A, 106: 291-301.

Nowiaski, A, 1971. *Nemegtosaurus mongoliensis* n.gen. n. sp. (Sauropoda) from the Uppermost Cretaceous of Mongolia. *Palaeontologia Polonica* 25:57-81.

Osborn, H.F., and Mook, C.C., 1921. *Camarasaurus, Amphicoelias,* and other sauropods of Cope. *Mernoires of the American Museum of Natural History,*N.S. 3: 247-287.

Salgado, L. And Calvo, J. 0., 1997. Evolution of titanosaurid sauropods. II: The cranial evidence. *Ameghiniana,* 34: 33-48.

Salgado, L. and Bonaparte, J. F., 1991. Un nuevo saurópodo Dicraeosauridae, *Amargasaurus cazaiti* gen. et sp. nov. de Ia Formación La Amarga, Neocomiano de la Prov. del Neuquén, Argentina. *Ameghiniana,* 28 (3-4): 333-346.

Santos, V.F., Lockley, M.G., Moratalla, J.J. and Galopim de Carvalho, A.M., 1992. The Longest dinosaur trackway in the world?. Interpretations of Cretaceous Footprints from Carenque, near Lisbon, Portugal. *GAlA* 5: 18-27.

Santos, V. F., Lockley, M.G., Meyer, C.A., Carvalho, J., Galopim de Carvalho, A.M., and Moratalla, J.J., 1994. A new sauropod tracksite from the Middle Jurassic of Portugal. *GAIA* 10: 5-13.

Schudack, M. and Schudack, U., 1989. Late Kimmeridgian to Berriasian paleogeography of the northwestern Iberian Ranges (Spain). *Berliner Geowissenschaftliche Abhandlungen,* A, 106: 445-457.

Wilson, J.A. and Sereno, P.C., 1998. Early evolution and higher- level phylogeny of Sauropod dinosaurs. *Memoir of the Society of Vertebrate Paleontology,* 5: 1-68.

Ziegler, P.A., 1988. Evolution of the Arctic North Atlantic and the Western Tethys. *Memoir A,nerican Association of Petroleum Geologists, 43:* 1-198.

BONAPARTE, J.F., & MATEUS, O. (1999). A new diplodocid, *Dinheirosaurus lourinhanensis* gen. et sp. nov., from the Late Jurassic beds of Portugal. Revista del Museo Argentino de Ciencias Naturales. 5(2):13-29.

www.dinodata.net/lusodinos