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Systematic Palaeontology (Vertebrate Palaeontology)

# The 'Giant of Ksour', a Middle Jurassic sauropod dinosaur from Algeria

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**Abstract**

Continental strata of Early and Middle Jurassic age are seldom-exposed, and little is known of the history of sauropod dinosaurs prior to the neosauropod radiation of the end of the Middle Jurassic. Here, we report, in the Middle Jurassic of the Occidental Saharan Atlas (Algerian High Atlas), the discovery of a skeleton, including cranial material, of a new cetiosaurid sauropod. *Chebsaurus algeriensis* n. g., n. sp. represents the most complete Algerian sauropod available to date, only few remains were found before. ***To cite this article: F. Mahammed et al., C. R. Palevol 4 (2005)***.


**Résumé**

**Le « Géant des Ksour », un dinosaure sauropode du Jurassique moyen d'Algérie**. Parce que les dépôts continentaux du Jurassique inférieur et moyen affleurent rarement, l'histoire des dinosaures sauropodes est très mal connue avant la radiation des néosauropodes, à la fin du Jurassique moyen. Nous rapportons ici la découverte, dans le Jurassique moyen de l'Atlas saharien occidental (Haut Atlas algérien), du squelette et du crâne d'un nouveau sauropode cétiosauride. *Chebsaurus algeriensis* n. g., n. sp. représente le sauropode algérien le plus complet connu à l'heure actuelle, seuls quelques restes épars ayant été trouvés auparavant. ***Pour citer cet article : F. Mahammed et al., C. R. Palevol 4 (2005)***.


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*Mots clés :* Dinosaures ; Sauropoda ; Jurassique moyen ; Algérie

## Version française abrégée

### *Introduction*

Nous décrivons ici le squelette d'un nouveau sauropode, incluant des restes crâniens, récolté dans une succession marno-calcaire (60 m d'épaisseur) intercalée par de gros bancs de grès, datée du Jurassique moyen [10,17] dans les monts des Ksour de l'Atlas saharien occidental (Haut Atlas algérien) (Fig. 1). D'autres restes de dinosaures sauropodes, ainsi que de théropodes de grande et moyenne taille, mais d'affinités incertaines pour le moment, ainsi que quelques troncs d'arbres non déterminés ont été découverts. Seul un fragment de bennettitale (Cycadeoidea) provenant du mont Larouya (légèrement plus récent que le mont Rouis El Djir) est bien préservé, mais ce végétal est commun à tout le Jurassique et ne peut donc pas nous fournir plus d'informations pour une datation plus précise du site.

### *Paléontologie systématique*

Dinosauria Owen, 1842 [23]
Saurischia Seeley, 1888 [25]
Sauropodomorpha Huene, 1932 [11]
Sauropoda Marsh, 1878 [18]
Cetiosauridae Lydekker, 1888 [16]
« Géant des Ksour » *Chebsaurus algeriensis* gen. et sp. nov.

*Étymologie*. Le nom du genre dérive du mot arabe *Cheb*, qui est une appellation populaire de la région ouest de l'Algérie pour désigner un adolescent de façon amicale et tendre (ce dinosaure étant mort au stade juvénile) et de *sauros*, lézard en grec. Le nom spécifique fait référence au pays dans lequel a été trouvé le dinosaure.

*Holotype*. D001–01 à 78 (Fig. 2), temporairement conservé au CRD de Sonatrach, Boumerdès, Algérie ; squelette partiel d'un sauropode juvénile, comprenant du matériel crânien, qui inclut un surangulaire, un fragment de basioccipital et des dents.

*Localité et horizon*. Mont de Rouis El Djir, Oulakak, Daïra de Sfissifa, Wilaya de Naama, Atlas saharien occidental, Algérie. Le site est à mi-pente du versant nord du mont Rouis El Djir, dans une série continentale détritique du Jurassique moyen indéterminé, qui recouvre les marno-calcaires du Jurassique inférieur [10,17,21].

*Diagnose*. Eusauropode primitif défini par les autapomorphies suivantes : un surangulaire gracile et allongé ; une surface tuberculée des couronnes et des racines des dents, des tubercules basioccipitaux courts et robustes qui divergent en formant un V et leurs facettes sont inclinées à environ 70° par rapport à l'horizontale en vue caudale (leur surface est elliptique et orientée avec un axe long cranio-dorsal) ; la base de la lame postzygo-diapophysiale (podl, [29]) du processus transverse est incluse dans la partie craniale de la postzygapophyse en vue latérale ; présence d'une petite fosse elliptique caudo-dorsalement aux excavations latérales (pseudo-pleurocoeles) sur un centrum de vertèbre dorsale moyenne.

*Chebsaurus* est un sauropode, car il possède des dents avec des facettes d'usure en forme de V, des couronnes dentaires spatulées (section en forme de D), avec une surface émaillée ridée, des centra de vertèbres cervicales opisthocoeles, un condyle proximal de l'ulna triradié, avec une fosse profonde pour accueillir le radius, une réduction du processus olécrânien et la phalange unguéale du premier doigt de pied en forme de faucille. Il s'agit également d'un eusauropode de par la forme de bloc des carpiens et la configuration étendue des métatarsiens [19,30,31].

### *Comparaisons et conclusions*

*Chebsaurus* devait mesurer dans les 8 à 9 m de long ; il s'agit d'un sauropode qui était encore au stade juvénile, car les centra de toutes ces vertèbres ne sont pas soudées aux arcs neuraux. *Chebsaurus* se différencie d'autres sauropodes du Jurassique inférieur et moyen (comme *Shunosaurus lii* et *Ferganasaurus verzilini* d'Asie, *Cetiosaurus oxoniensis* d'Europe, *Patagosaurus fariasi* d'Amérique du Sud, *Tazoudasaurus naimi* et *Atlasaurus imelakei* d'Afrique du Nord, *Vulcanodon karibaensis* d'Afrique du Sud) sur la base de nombreux caractères anatomiques.

*Chebsaurus* est le sauropode le plus complet trouvé à ce jour en Algérie. Il présente nombre d'affinités avec les taxons *Lapparentosaurus madagascariensis* (formation Isalo III, Bathonien, Madagascar [3]), *Cetiosaurus oxoniensis* (formation Forest Marble, Bathonien, Grande-Bretagne [28]) et « *Cetiosaurus oxoniensis* » (formation Rutland, Bajocien, Grande-Bretagne [27]) (voir ci-dessous § *Material and comparisons*).

Dans l'attente de trouver le restant de l'animal, une description plus détaillée ainsi qu'une étude phylogénétique seront nécessaires pour tester ces affinités (Läng et Mahammed, en préparation).

## 1. Introduction

Sauropod remains were documented from the Early and Middle Jurassic strata of North Africa by Moroccan sauropods through the descriptions of « *Cetiosaurus* » *mogrebiensis* [13], *Atlasaurus imelakei* [22] and more recently *Tazoudasaurus naimi* [2]. In Algeria, Lapparent and Lucas [15] report the discovery of about 10 middle caudal vertebrae of an indeterminate sauropod from the Middle Jurassic (Callovian) in the Rhar Rouban region (15 km southeast of Oujda, Algeria).

Recently, we collected parts of a sauropod skeleton, including cranial material, discovered in a detrital series about 60-m thick intercalated between sandstone bars from the Middle Jurassic [10,17] of the Occidental Saharan Atlas (Algerian High Atlas), in the Ksour Mountains (Fig. 1). Sauropod remains were found associated with other indeterminate sauropod bones and theropod teeth. A bennettitale (Cycadeoidea) fragment was preserved in the Larouya mount (slightly more recent than the Rouis El Djir Mount) near the site, but this vegetal is representative of the Jurassic flora and does not provide a better support to date the site.

## 2. Systematic palaeontology

Dinosauria Owen, 1842 [23]
Saurischia Seeley, 1888 [25]
Sauropodomorpha Huene, 1932 [11]
Sauropoda Marsh, 1878 [18]
Cetiosauridae Lydekker, 1888 [16]
'Géant des Ksour' *Chebsaurus algeriensis* gen. et sp. nov.

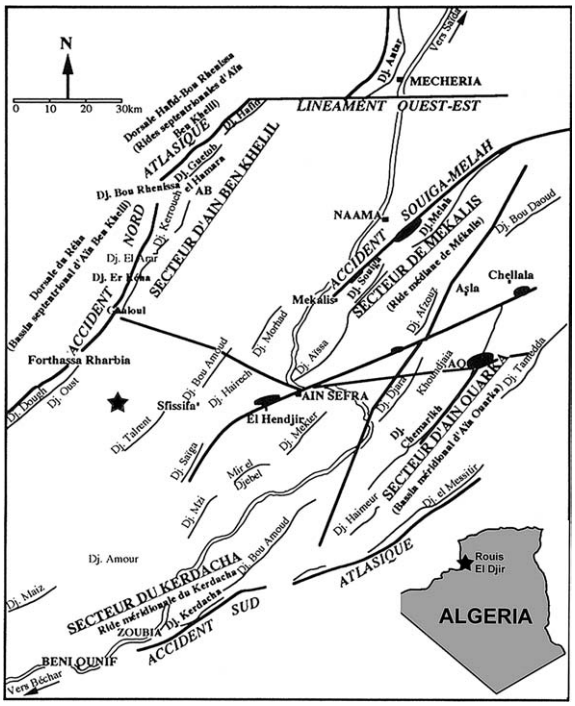


Fig. 1. Location of various sectors in the Ksour Mountains (modified after Mekahli [21]). The site is marked with a star.
Fig. 1. Localisation des secteurs dans le cadre des Monts des Ksour (modifié d'après Mekahli [21]). Le site est localisé par une étoile.

**Etymology.** The generic name is from the Arab word *Cheb*, which designates a teenager, in a friendly and tenderly way in the West Algerian region (this sauropod being a juvenile), plus *sauros*, Greek for lizard. Specific name is from Algeria, referring to the site country.

**Holotype**. D001–01 to 78 (Fig. 2), temporarily in Sonatrach CRD, Boumerdès, Algeria; partial skeleton and cranial material of a juvenile sauropod including a part of basioccipital, a surangular and teeth.

**Locality and horizon.** Rouis El Djir mount, Oulakak, Sfissifa daïra, Naama wilaya, Occidental Saharan Atlas, Algeria. The site is at mid-slope of the Rouis El Djir mount on its northern hillside, in a continental detrital series from the indeterminate Middle Jurassic that overlaps the clay-limestones series from the Early Jurassic [10,17,21].

**Diagnosis**. Primitive eusauropod displaying the following autapomorphies: a slender and elongated surangular; teeth crown and root with tuberculated surface; short and robust basioccipital tubera which diverge with a V-shape (60°) and their facets are inclined at

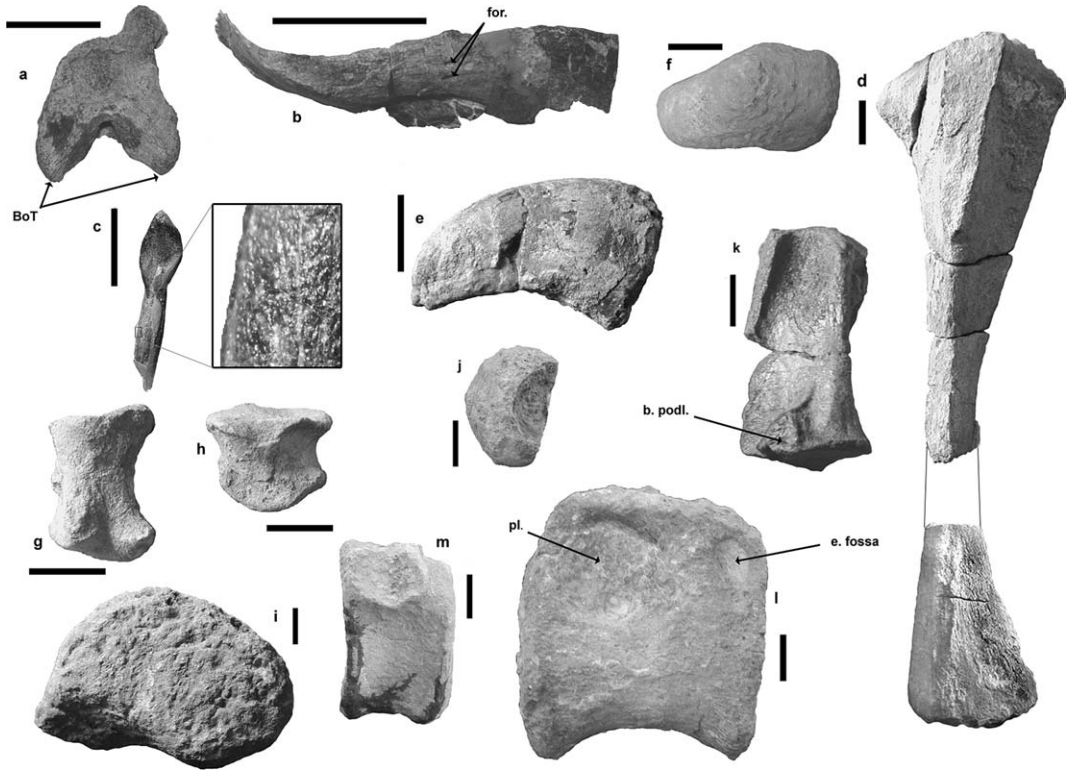


Fig. 2. Elements of the holotypic material of *Chebsaurus algeriensis*. (**a**) D001-63 basioccipital in caudal view; (**b**) D001-77 right surangular in lateral view; (**c**) D001-78 tooth in lingual view, with an enlargement of the root surface texture; (**d**) D001-32 right ulna in medial view; (**e**) D001-08 ungual phalanx in lateral view; (**f**) D001-49 carpal bone; (**g**) D001-02 pedal phalanx in palmar view; (**h**) D001-01 manual phalanx in dorsal view; (**i**) D001-36 proximal end of right pubis in proximal view; (**j**) D001-15 cranial portion of cervical centrum in left lateral view; (**k**) D001-35 dorsal neural spine in left lateral view; (**l**) D001-17 dorsal centrum in left lateral view; (**m**) D001-20 caudal centrum in left lateral view. Scale bars are 3 cm for all, except (**c**): 2 cm. Abbreviations: **BoT.**, Basioccipital tubera; **b. podl.**, base of the postzygodiapophysial lamina; **e. fossa**, elliptic fossa; **for.**, foramen; **pl.**, pleurocoel.

Fig. 2. Éléments de l'holotype de *Chebsaurus algeriensis*. (**a**) D001-63 basioccipital en vue caudale ; (**b**) D001-77 surangulaire droit en vue latérale ; (**c**) D001-78 dent en vue linguale, avec un agrandissement de la texture de la surface de la racine ; (**d**) D001-32 ulna droite en vue médiale ; (**e**) D001-08 phalange unguéale en vue latérale ; (**f**) D001-49 os carpien ; (**g**) D001-02 phalange du pied en vue palmaire ; (**h**) D001-01 phalange de la main en vue dorsale ; (**i**) D001-36 extrémité proximale du pubis droit en vue proximale ; (**j**) D001-15 fragment cranial de centrum de vertèbre cervicale en vue latérale gauche ; (**k**) D001-35 épine neurale de vertèbre dorsale en vue latérale gauche ; (**l**) D001-17 centrum de vertèbre dorsale en vue latérale gauche ; (**m**) D001-20 centrum de vertèbre caudale en vue latérale gauche. Barres d'échelle : 3 cm, à part (**c**) : 2 cm. Abréviations : **BoT.**, tubercules basioccipitaux ; **b. podl.**, base de la lame postzygo-diapophysiale ; **e. fossa**, fosse elliptique ; **for**., foramen ; **pl.**, pleurocoele.

about 70° to the horizontal in caudal view (their elliptical surface is oriented with a craniodorsal long axis); the base of the transverse process postzygodiapophysial lamina (podl, [29]) of the is included within the cranial part of the postzygapophysis in lateral view; there is a small elliptical fossa caudodorsally to the lateral excavations (pseudopleurocoels) on one middle dorsal vertebra centrum.

*Chebsaurus* is a sauropod, because it possesses teeth with V-shaped wear facets, spatulate (D-shaped) teeth crown with a wrinkled enamel surface texture, opisthocoelous cervical centra, a triradiate proximal condyle of ulna with a deep radial fossa, a reduction of an olecranon process on ulna and the pedal ungual of the first digit is sickle-shaped. We can specify that it is an eusauropod by the block-shaped carpal bones and the spreading metatarsus configuration [19,30,31].

It is not a neosauropod because the dorsal surfaces of the cervical parapophyses are excavated and they are not separated from the lateral excavation by a ridge [26] and because it possesses marginal tooth denticles on the anterior margin of crown [5,20,30].

## 3. Material and comparisons: preliminary description

*Chebsaurus* was a small, ~ 8–9-m-long sauropod that was at a juvenile stage because vertebra centra are not fused with its neural arches. A piece of the **basicranium** (D001–63) corresponds to the junction between basioccipital and basisphenoid, at the level of basal tubera (basioccipital tubera [BoT] for the basioccipital part and basisphenoid tubera [BsT] for the basisphenoid part). In caudal view, BoT are short and robust; they diverge from one another at an angle of about 60° with a V-shape (30–35° in *Rapetosaurus* [8]; BoT are thicker and more bulbous in *Shunosaurus* [6 (Fig. 5B)]) and their facets are inclined at about 70° to the horizontal in caudal view. Their surface is elliptical and oriented with a craniodorsal long axis. In lateral view, the arching neck between the occipital condyle and the BoT is missing. Between BsT, a deep fossa is pierced by several small foramina.

The lower jaw is represented by a long **surangular** (D001–77), broken cranially, which exhibits a smooth, sigmoidal curvature in lateral view and in dorsal view. It tapers caudally. Unlike the high and robust surangular of *Atlasaurus* (Läng, pers. obs.) or *Shunosaurus* [6], this is very low, long and slender (as *Euhelopus* [32]). On about the middle third of the lateral surface of the surangular, there are two oval (anteroposteriorly elongated) neurovascular foramina side by side and the dorsal margin gets thicker with prominent medial and lateral edges. In *Atlasaurus*, these two foramina are situated on the caudal third of the lateral surface (Läng, pers. obs.).

The dentary crown has a horizontal section in D-shape (spatulate **teeth** D001–78). The enamel is wrinkled as in other sauropods [30,31], and its texture is composed of many tubercles (without orientation) that we observe again on the root surface. *Lapparentosaurus* shows the same texture on its teeth crown surface but its root is slightly smooth with fine longitudinal ridges (Läng, pers. obs.). Only the neck is smooth and is very tightened as in *Lapparentosaurus*. Occlusal pattern is V-shaped as in primitive sauropods [26,30,31]. Teeth are all isolated so there is no possibility to know the crown orientation. As in *Mamenchisaurus* and *Omeisaurus*, denticles are present on the cranial margin of teeth crowns (on cranial and caudal margins in *Tazoudasaurus*; absent on both margins in Neosauropoda) [26,30].

The bone structure of the **presacral vertebrae** is solid. Parts of **proatlas** and **axis** as six incomplete **cervical centra** were found. All cervical centra are opisthocoelous as within all sauropods [19,30]. The high/diameter ratio of cranial cervicals centra is more than 1 (1.14 for D001–15) as Chinese eusauropods (*Euhelopus, Mamenchisaurus, Shunosaurus, Omeisaurus*) [26]. Dorsal surfaces of the cervical parapophyses are excavated, but they are not separated from the pleurocoel by a ridge (unlike neosauropods). Pleurocoels seem to be simple and not divided. No cervical neural arc was found. The caudal part of centra is always missing, except for the smaller vertebra.

Six anterior and middle **dorsal centra** (among two incomplete), notably cranial centra, are amphicoelous as in *Lapparentosaurus* but the cranial end is very slightly more convex and the caudal end is very shallowly more concave, as in middle dorsals in *Patagosaurus*. They possess deep excavations on their lateral surfaces as in all sauropods (except *Shunosaurus, Mamenchisaurus, Lapparentosaurus, Malawisaurus* and Dicraeosauridae) [26], but it is rather simple pit (pseudopleurocoel), which is not extensively ramified within the centrum as in *Cetiosaurus oxoniensis* from Oxford and '*Cetiosaurus oxoniensis*' from Leicester and which lies on the cranial two-third of the lateral surface. In lateral view, on the caudodorsal part of one vertebra centrum (?6$^{th}$, D001–17), there is also a small rather deep elliptic fossa (with a large craniodorsal diameter of 25 mm and a short cranioventral diameter of 15 mm). This feature is not found within other sauropods so it is regarded as an autapomorphy in this study. Just one caudal part of a dorsal neural spine was found and there is no complete neural arc. In dorsal view, the spine is at once lengthened craniocaudally (as *Lapparentosaurus* and '*Cetiosaurus oxoniensis*' from Leicester) and at once somewhat widened transversely (crosswise-like): very thin at the centre and very widened transversely with robust spinoprezygapophysial and spinopostzygapophysial laminae cranially and caudally, respectively. The spinopostzygapophysial lamina (spol) is single (as in *Lapparentosaurus*, *Cetiosaurus*, and *Shunosaurus*). Postzygapophyses have an ovoid plane surface with a craniocaudally long axis that faces ventrally and very slightly laterally. In lateral view, forwards, in the postzygapophysis, there is the base of the postzygodiapophysial lamina of transverse process. It is remarkable in this specimen that the base of

this lamina is included within the postzygapophyses; in other specimens, it is well separated: cranial to the postzygapophysis. So this character state is regarded as an autapomorphy.

The only **sacral centrum** (D001–19) is very eroded.

Only three cranial middle **caudal vertebrae** were found (one complete, one incomplete and one very eroded). As *Ferganasaurus*, *Lapparentosaurus* and *Cetiosaurus*, they are amphicoelous and do not show lateral excavations. The length/height ratio of anterior caudal centra is about 0.63 (D001–20) as in many eusauropods (except in *Malawisaurus* and Titanosauridae without *Opisthocoelicaudia*) [26]. The suture with the neural canal lies on the cranial two-third of the centrum, as in many sauropods. The caudoventral margin bears chevron facets on D001–20 (others caudals centra are too less preserved to determine that).

The **scapular blade** (D001–52) has an elliptical-like section, with a thicker caudoventral border and a thinner craniodorsal border, as *Lapparentosaurus* and *Patagosaurus*. The caudoventral border presents a narrow furrow as in *Lapparentosaurus*.

The two heads of each **humerus** (D001–31 and 41) are available. They have the characteristic spoon shape of all sauropod (with a concave cranial and a convex caudal side). The proximal margin is rounded and the articular head is projected backward. In proximal view, the cranial margin is relatively straight (not sigmoid in a transverse section as in *Lapparentosaurus* or *Ferganasaurus*, where the lateral border is curved towards front to form the beginning of the deltopectoral crest). The right **ulna** (D001–32) is nearly complete; the left is reported by the cranial branch of its proximal end and by the distal end. The proximal end of the ulna is triradiate and forms a deep radial fossa as in most of sauropods [30,31,33]. The ulnar olecranon process is low and reduced, at the level of the proximal articulation as in sauropods [30,31]. It is gracile as in *Lapparentosaurus* (midshaft width/length ratio about 10% in *Chebsaurus* and *Lapparentosaurus*). Only the proximal end of the right **radius** (D001–34) is available and presents a caudomedial beak. **Carpal bones** are block-shaped as in eusauropods [30,31] with a rounded palmar surface and a flattened dorsal surface as in *Lapparentosaurus* (both flattened surfaces in *Shunosaurus, Diplodocus*). No **metacarpal bone** (D001–25 to 28) is complete, only ends are preserved but their assemblage is semitubular as in many eusauropods [26,33]. A nonungual **phalanx** (D001–01) is broader transversely than long craniocaudally as in eusauropods. **Manual unguals** (D001–08 to 10) are sickle-shaped and much deeper dorsoventrally than broad transversely as in eusauropods, those of the digit I being the largest [30,31].

There are many flat pieces that should be part of **ilium**. The ischiatic peduncle (D001–37) is triangular in caudoventral view. Its cranioventral part, which participates to the acetabulum, is flat. The **pubis** (D001–36), represented by its proximal end, has a poorly developed ambiens process. The extremity of this process is rather rounded in both lateral and proximal views whereas in *Lapparentosaurus* it is more developed: rather tapered in proximal view and mildly prominent forward in lateral view.

Hindlimbs are represented by the distal end of a **fibula** (D001–40) that presents a distal condyle with a medial margin expanded transversely, more than twice the mid-height diameter as *Barapasaurus, Mamenchisaurus* and *Brachiosaurus*. The assemblage of **metatarsus** (D001–03 to 07) has a spreading configuration as in eusauropods [7,12,14,18,20,30]. The transverse axis of its proximal condyle of the Mt I is perpendicular to its long axis (as *Rayososaurus, Patagosaurus* and *Barapasaurus*). Mt I is short and very robust as in many eusauropods [26]. A nonungual **phalanx** (D001–02) is rectangular and more elongated craniocaudally than transversely. **Pedal unguals** (D001–29, 38, 39, 48, 60) are sickle-shaped and much deeper dorsoventrally than broad transversely as in eusauropods and those of the digit I is the largest [30,31].

## 4. Conclusion

*Chebsaurus* is the most complete sauropod skeleton found in Algeria. It allows us to fill out the Middle Jurassic sauropod register in an anatomical and systematical viewpoint.

Compared to the other well-preserved Early Jurassic sauropod skeletons like *Vulcanodon* (Vulcanodon Beds, Mashonaland North, Zimbabwe [24]), *Tazoudasaurus* (Toarcian continental detrital series, Toundoute, Morocco [2]) and Middle Jurassic sauropod skeletons, including *Shunosaurus* (Xiashaximiao Formation, Sichuan, China [9,34]), *Ferganasaurus* (Balabansai Formation, Fergana Valley, Kirghizia [1]),

*Patagosaurus* (Cañadon Asfalto Formation, Chubut, Argentina [4]), and *Atlasaurus* (Wawmda, Central High Atlas, Morocco [22]), *Chebsaurus* is different on the basis of numerous anatomical characters. But it shows much more affinities with the Middle Jurassic taxa *Lapparentosaurus madagascariensis* (Isalo III Formation, Bathonian, Madagascar [3]), *Cetiosaurus oxoniensis* (Forest Marble Formation, Bathonian, Great Britain [28]) and '*Cetiosaurus oxoniensis*' (Rutland Formation, Bajocian, Great Britain [27]): the neck of teeth rather very tightened, amphicoelous dorsal and caudal centra (the latter lack excavations on their lateral sides), a single spinopostzygapopysial lamina on dorsal neural spine, gracile ulna, carpal bones with a rounded ventral and a flattened dorsal surfaces.

Looking forward to discovering the remainder of the dinosaur, a more detailed description of this new specimen as well as a phylogenetic study will be necessary to test the monophyly of this Middle Jurassic group (Läng and Mahammed, in prep.). It might be a comeback to Bonaparte's hypothesis (basing on vertebral anatomy) [3] that proposed to form a Cetiosauridae monophyletic group composed of *Lapparentosaurus, Volkheimeria*, on the one hand, and *Barapasaurus, Cetiosaurus* and *Patagosaurus*, on the other hand.

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