

An early trend towards gigantism in Triassic sauropodomorph dinosaurs

Cecilia Apaldetti^{1,2*}, Ricardo N. Martínez¹, Ignacio A. Cerda³, Diego Pol² and Oscar Alcober¹

Dinosaurs dominated the terrestrial ecosystems for more than 140 Myr during the Mesozoic era, and among them were sauropodomorphs, the largest land animals recorded in the history of life. Early sauropodomorphs were small bipeds, and it was long believed that acquisition of giant body size in this clade (over 10 tonnes) occurred during the Jurassic and was linked to numerous skeletal modifications present in Eusauropoda. Although the origin of gigantism in sauropodomorphs was a pivotal stage in the history of dinosaurs, an incomplete fossil record obscures details of this crucial evolutionary change. Here, we describe a new sauropodomorph from the Late Triassic of Argentina nested within a clade of other non-eusauropods from southwest Pangaea. Members of this clade attained large body size while maintaining a plesiomorphic cyclical growth pattern, displaying many features of the body plan of basal sauropodomorphs and lacking most anatomical traits previously regarded as adaptations to gigantism. This novel strategy highlights a highly accelerated growth rate, an improved avian-style respiratory system, and modifications of the vertebral epaxial musculature and hindlimbs as critical to the evolution of gigantism. This reveals that the first pulse towards gigantism in dinosaurs occurred over 30 Myr before the appearance of the first eusauropods.

The Late Triassic period (~237–201 million years ago (Ma)) was a crucial moment in the evolutionary history of terrestrial vertebrates, during which numerous extinctions, diversifications and faunal radiations changed the ecosystem dynamics throughout the world^{1–8}. Among the new lineages that arose at that moment, dinosaurs had a central role, evolving into numerous forms that occupied different niches in terrestrial ecosystems. Sauropodomorpha was the first successful group of herbivorous dinosaurs, dominating most terrestrial ecosystems for more than 140 Myr, from the Late Triassic to Late Cretaceous^{9–11}. The sauropodomorph radiation in the Late Triassic is evident by the appearance of many small, gracile and bipedal taxa recorded throughout the world (a paraphyletic assemblage formerly known as ‘prosauropods’). Sauropods evolved from these smaller forms and became the largest land animals that ever lived on Earth^{12–17}.

The evolution from small bipedal to giant quadrupedal sauropodomorphs involved numerous anatomical changes, such as decreased skull size, elongation of the neck and forelimbs, highly pneumatic vertebrae, columnar limbs, tubular metacarpal, reduction of the phalanges and acyclical bone growth^{12–15,18–20}. The simultaneous presence of all these features characterizes the body plan of Eusauropoda (true sauropods)—the clade that evolved into giant forms reaching up to 70 tonnes in the late Mesozoic^{16,17,21,22}. Here, we present a new non-eusauropod sauropodomorph and three new specimens of *Lessemsaurus sauroipoides*, all from the Late Triassic of Argentina, which show the presence of a novel growth strategy that allowed them to attain large body sizes without having the anatomical traits previously regarded as adaptations to gigantism in eusauropods.

Results

Systematic palaeontology.

Dinosauria Owen, 1842

Saurischia Seeley, 1888

Sauropodomorpha von Huene, 1932

Lessemsauridae clade nov.

Etymology. Related to *L. sauroipoides* Bonaparte, 1999.

Definition. The clade *Lessemsauridae* is defined here as *L. sauroipoides* Bonaparte, 1999 and *Antetonitrus ingenipes* Yates and Kitching, 2003, and all the descendants from their most common ancestor.

Diagnosis. *Lessemsauridae* differs from all other Sauropodomorpha dinosaurs in possessing the following unique character state combination (asterisks indicate apomorphies of the clade): robust scapulae with dorsal and ventral ends equally expanded*; bone growth characterized by the presence of thick zones of highly vascularized fibrolamellar bone, within a cyclical growth pattern*; slit-shaped neural canal of posterior dorsal vertebrae; anterior dorsal neural spines transversely expanded towards the dorsal end; and a minimum transverse shaft width of the first metacarpal greater than twice the minimum transverse shaft of the second metacarpal.

Ingentia prima gen. et sp. nov.

Etymology. ‘*Ingentia*’, huge (fem., Latin); ‘*prima*’, first (fem. Latin), referring to the large body size acquired during the early evolution of Dinosauria.

Holotype. Paleovertebrado Instituto y Museo de Ciencias Naturales, Universidad Nacional de San Juan, San Juan, Argentina (PVSJ) 1086. Six articulated posterior cervical vertebrae (C5–C10), glenoid region of right scapula and right forelimb lacking all phalanges (except phalanx IV.1 and V.1–2; Fig. 1 and Supplementary Table 1).

Locality and horizon. Southern outcrops of the Quebrada del Barro Formation, Marayes–El Carrizal Basin, northwestern Argentina, late Norian–Rhaetian age²³ (Supplementary Fig. 1). The type horizon is located 160 m below the top of the formation (Supplementary Information).

¹Instituto y Museo de Ciencias Naturales, Centro de Investigaciones de la Geósfera y la Biosfera (CIGEOBIO), Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de San Juan, San Juan, Argentina. ²CONICET-Museo Paleontológico Egidio Feruglio, Trelew, Argentina. ³CONICET-Instituto de Investigación en Paleobiología y Geología, Museo Carlos Ameghino, Universidad Nacional de Río Negro, Río Negro, Argentina. *e-mail: capaldetti@unsj.edu.ar

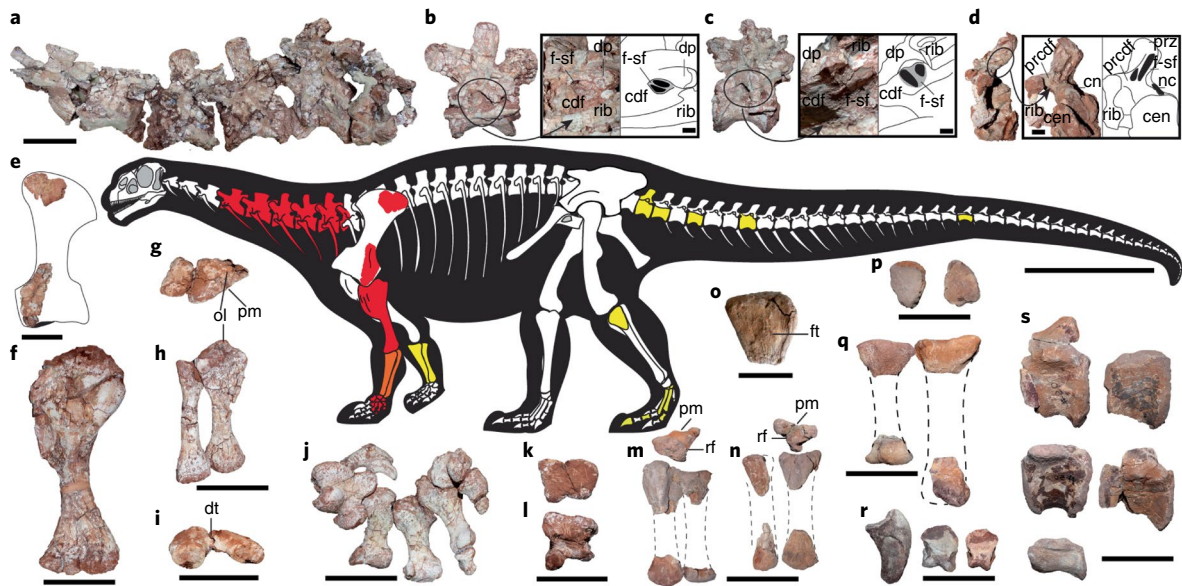


Fig. 1 | Skeletal anatomy of *Ingentia prima* gen. et sp. nov. from the Quebrada del Barro Formation, northwestern Argentina. a–k, Holotype (PVSJ 1086). l–s, Referred material (PVSJ 1087). a–d, Mid-posterior cervical vertebrae, C5–C10 articulated series (a), close up of the pneumatic fossa with internal subfossae on the centriadiapophyseal fossa (cdf)²⁶ of C8 (b) and C9 (c), and a complex of subfossae on the prcdf²⁶ of C10 (d). e, Right partial scapula. f–i, Right forelimb: humerus (f), and the radius and ulna in proximal (g) and anterior (h) view, and distal articulation (i). j, Right manus in plantar view. k, l, Metacarpal I in proximal (k) and dorsal (l) view. m, n, Radius and ulnae with respective proximal ulna: right radius-ulna (m) and left radius-ulna (n) in posterior view. o, Left proximal end of fibula. p–r, Right partial pes: distal tarsal III–IV in proximal view (p), metatarsal I and II in dorsal view (q) and isolated phalanges (r). s, Four anterior caudal vertebrae and a distal one (bottom left). cen, centrum; dp, diapophysis; dt, distal tubercles of radius-ulna; f-sf, fossa-subfossae complex; ft, fibular tubercle; nc, neural canal; ol, olecranon; pm, posteromedial margin of the ulna; prz, prezygapophysis; rf, radial fossa; rib, rib. Scale bars: 10 cm in a and i–s; 2 cm in b–d; 20 cm in e–h; 120 cm for the skeleton. Red, holotype; yellow, referred specimen; orange, holotype and referred specimen.

Diagnosis. Mid-cervical neural arches almost twice as high as their respective centra; vertebrae C6–C10 with hyposphenes as tall as the neural canal height; pneumatic structures on posterior cervical neural arches, including deep fossae on the centriadiapophyseal fossa (cdf), with internal subfossae in C8–C9, and a complex of subfossae in the prezygapophyseal centriadiapophyseal fossa (prcdf) in C10*; expanded proximal end of the ulna with a posteromedial margin 1.5 times larger than the radial fossa margin* (*autapomorphies; Fig. 1).

Osteological and histological description. The cervical vertebrae are tall, with the tallest neural arch twice as high as its posterior centrum articular surface. The postzygapophyses are elevated with respect to prezygapophyses, as in other sauropods^{24,25}. From vertebra C6, the hyposphenes are as tall as the height of the neural canal (Fig. 1), similar to *Lessemsaurus*, *Aardonyx* and *Meroktenos* (Supplementary Fig. 4). The posterior cervical vertebrae have a unique combination of pneumatic structures (Fig. 1; see Supplementary Information): in vertebrae C8–C9, the cdf²⁶ is invaded by a deep fossa, with two shallow concavities inside it (Fig. 1b,c); and C10 has a complex of two deep subfossae within the prcdf²⁶. Deep fossae within the cdf and prcdf are also present on the posteriormost cervical vertebrae of *Lessemsaurus* (Paleovertebrado Instituto Miguel Lillo, Tucumán, Argentina (PVL) 4822-1), although the prcdf seems to lack internal subfossae (Supplementary Fig. 4). Except for a few specimens of *Plateosaurus* that have incipient pneumatic fossae within fossae on cervico-dorsal neural arches²⁷, the combination of well-developed pneumatic structures of the cervical vertebrae of *Ingentia* is unique among Sauropodomorpha (see Supplementary Information). The humerus has a marked distal flexor fossa, as in *Lessemsaurus* and non-sauropod sauropodomorphs. The deltopectoral crest extends 40% of the total length of the humerus, as in Sauropodiformes. The posteromedial margin of the proximal end

of the ulna is more than 1.5 times longer than the anterior (that is, radial fossa) margin, differing from all non-eusauropod sauropodomorphs (for example, *Lessemsaurus*, *Antetonitrus* and *Mussaurus*) in which the anterior margin is equal or larger than the posteromedial margin. The olecranon is poorly developed, as in *Lessemsaurus*, *Antetonitrus* and other sauropods. The metacarpals are proximodistally short, with a notably robust metacarpal I that is wider than it is long (Supplementary Table 1), as in other sauropodiforms such as *Aardonyx*, *Sefapanosaurus*, *Lessemsaurus* and *Antetonitrus*, but different from the enlarged first metacarpal of other sauropodomorphs (for example, *Plateosaurus*, *Mussaurus* and Neosauropoda).

The humeral histology of *Ingentia* preserves well-defined growth lines throughout the cortical bone that reveal a cyclical growth pattern as in non-sauropod sauropodomorphs¹⁹. However, there are remarkably thick zones of well-vascularized fibrolamellar bone indicative of high rates of bone tissue formation in the active phases of growth, as in sauropods (Fig. 2 and Supplementary Fig. 6).

Lessemsaurus sauropoides Bonaparte 1999, Pol and Powell 2007

New referred material. Centro Regional de Investigaciones Científicas y Transferencia Tecnológica de La Rioja, La Rioja, Argentina (CRILAR) PV-303: both partial scapulae lacking distal ends; CRILAR PV-302: left ilium, articulated ischia; PVL 6580: distal third of right femur (Supplementary Fig. 2 and Supplementary Information).

Locality and horizon. Upper levels of the Los Colorados Formation (mid-Norian²⁸), Ischigualasto–Villa Unión Basin, northwestern Argentina (see Supplementary Information).

Osteological and histological description. The scapulae have markedly expanded dorsal blades with strongly concave ante-

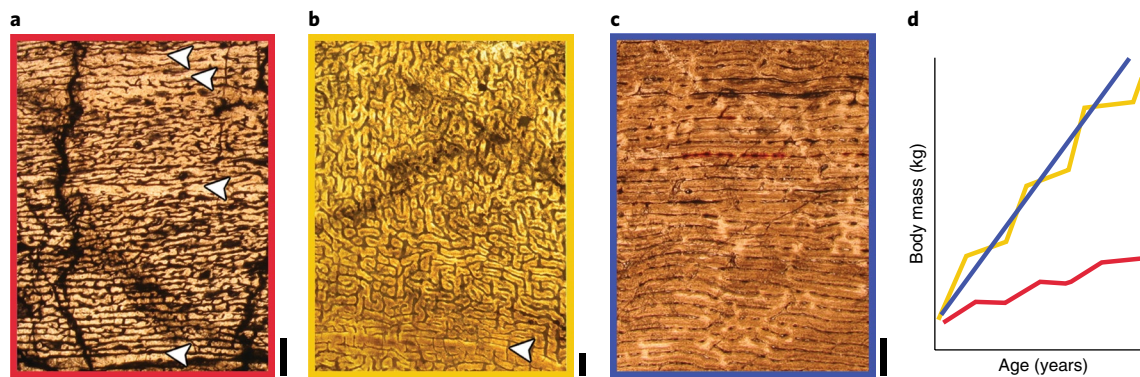


Fig. 2 | Bone histology and growth strategies in sauropodomorph dinosaurs. **a–c**, Femur bone histology of the basal sauropodomorph *Riojasaurus incertus* PVL 3669 (**a**), the lessemsaurid *L. sauroipoides* PVL 5680 (**b**) and the eusauropod *Volkheimeria chubutensis* PVL 7047 (**c**). Abundant growth marks and the predominance of longitudinal and circumferential vascular spaces are the common pattern in basal sauropodomorphs (**a**). The cortical bone of eusauropods is formed by uninterrupted deposited laminar bone (**c**), whereas a combination of plexiform and reticular bone interrupted by few growth marks (arrowheads) is observed in lessemsaurids (**b**). Scale bars: 0.5 mm. **d**, Schematic growth trajectories along three annual growth cycles in the early life history of the different Sauropodomorpha species shown using corresponding colours in **a–c**. Cyclical formation of growth marks (indicated by periodical diminutions in the pendent of growth curves) is enhanced to remark the different patterns. Despite lessemsaurids exhibiting the same strategy exploited by basal sauropodomorphs, cyclical pulses of accelerated growth allow the achievement of very large body sizes.

rior and posterior borders—apomorphies of *Lessemsaurus* and *Antetonitrus*^{29–31} (see Supplementary Information). Overall, the morphology of the ilium resembles other non-eusauropod sauropodomorphs, but bears two autapomorphies of *Lessemsaurus* (medial wall of the pubic peduncle extending to the acetabulum and extended brevis crest²⁹). The femur shares general features present in the type material and differs from other sauropodomorphs from the same formation mainly in the shaft and tibiofibular condyle morphology (Supplementary Fig. 2; see also Supplementary Information).

Histological samples of the femora of *Lessemsaurus* exhibit well-defined growth lines throughout the cortical bone and notably thick zones (>10 mm) of highly vascularized reticular fibrolamellar bone tissue between the growth lines (Supplementary Fig. 7), indicating a highly accelerated growth rate (see Supplementary Information). The abundance of plexiform and reticular cortical bone tissue in *Lessemsaurus* (Supplementary Figs. 7 and 8) differs from the laminar vascularization typical of eusauropods and their closest relatives, such as *Isanosaurus*³².

Despite sampling different appendicular elements for *Lessemsaurus* (femur) and *Ingentia* (humerus), both have thick zones of highly vascularized fibrolamellar bone within a cyclical growth pattern, suggesting a common growth strategy that is different from that reported for *Isanosaurus* and eusauropod dinosaurs¹⁹. Previous studies have reported that the highest known values of zone thickness among eusauropods reached 4,343 μm ³², which, when used as a proxy for growth rates (that is, by dividing the thickness of these annual growth cycles by 365 d), yielded maximum values below 12 $\mu\text{m d}^{-1}$. These zone thicknesses in the sampled femora of *Lessemsaurus* vary between 7,200 and 13,600 μm , implying growth rates of 20–37 $\mu\text{m per day}$ (Fig. 2). This unusual high growth rate detected in a lessemsaurid specimen (PVL 3669), which is twice or three times faster than in other sauropods, could explain the size of the other larger specimens here referred to as *Lessemsaurus* (that is, CRILAR-PV 302–303; see Supplementary Information). Previous body mass estimates for *Lessemsaurus* based on the type material were ~2 tonnes^{16,17}, but the unfused neural arches of cervical vertebrae of the holotype²⁹ and the absence of the outer circumferential layer or reduction in zone thickness in the referred femur (PVL 6580) suggest that these specimens of *Lessemsaurus* were not fully skeletally mature at the time of death. Two of the new specimens

of *Lessemsaurus* are larger than the holotype (for example, scapular proximodistal length: 80 cm; ilium anteroposterior length: 75 cm) and similar in size to that of Early Jurassic basal gravisaurians^{33,34}, whose body mass has been estimated in the range of 8–10 tonnes¹⁷ (see Supplementary Information and Supplementary Table 2). Similarly, a linear regression of iliac measurements versus inferred body mass¹⁷ in basal sauropodomorphs in fact suggests a body mass of over 7 tonnes for the specimen of *Lessemsaurus* represented by the ilium (Supplementary Fig. 3b,c and Supplementary Table 2; see also Supplementary Information).

Phylogenetic analysis. We assessed the phylogenetic affinities of *Ingentia* using the dataset and protocols presented in previous studies^{35,36} (see Methods and Supplementary Information). Our phylogenetic result recovered *Ingentia*, *Lessemsaurus* and *Antetonitrus* to form a clade, named here as Lessemsauridae (Fig. 3 and Supplementary Fig. 9; see also Supplementary Information). Under the most broadly used phylogenetic definitions for sauropodomorph clade names³⁵ (see Methods), Lessemsauridae would be considered the basal-most sauropod clade or, alternatively, one of the closest relatives of Sauropoda if a more restrictive definition is used^{25,31,37}.

Discussion

Implications of the origin of gigantism. The mid-Norian age of *Lessemsaurus*²⁸—the oldest lessemsaurid—indicates the appearance of an early trend towards large body size (equal to or approximating the body mass of basal gravisaurians such as *Vulcanodon* or *Tazoudasaurus*) at least 15 Myr earlier than previously thought (that is, *Vulcanodon* ~199–188 Ma³⁸; Fig. 3). The combination of reticular and plexiform bone observed in *Lessemsaurus* has recently been reported for *Antetonitrus*³⁹, which together with the presence of well-vascularized fibrolamellar bone in all lessemsaurids, indicates that this clade was able to attain large body sizes through a strategy of accelerated growth distinct from that associated with gigantism in eusauropods^{19,20}.

Gigantism in eusauropods has been proposed as the result of a complex interplay of anatomical, physiological and reproductive intrinsic traits^{12–20}. In this context, their elongated neck was interpreted as a key acquisition that—among others—improved heat loss allowed by the avian-like cervical air sacs and the neck's high surface-to-volume ratio, as required given the high metabolic rate inferred for

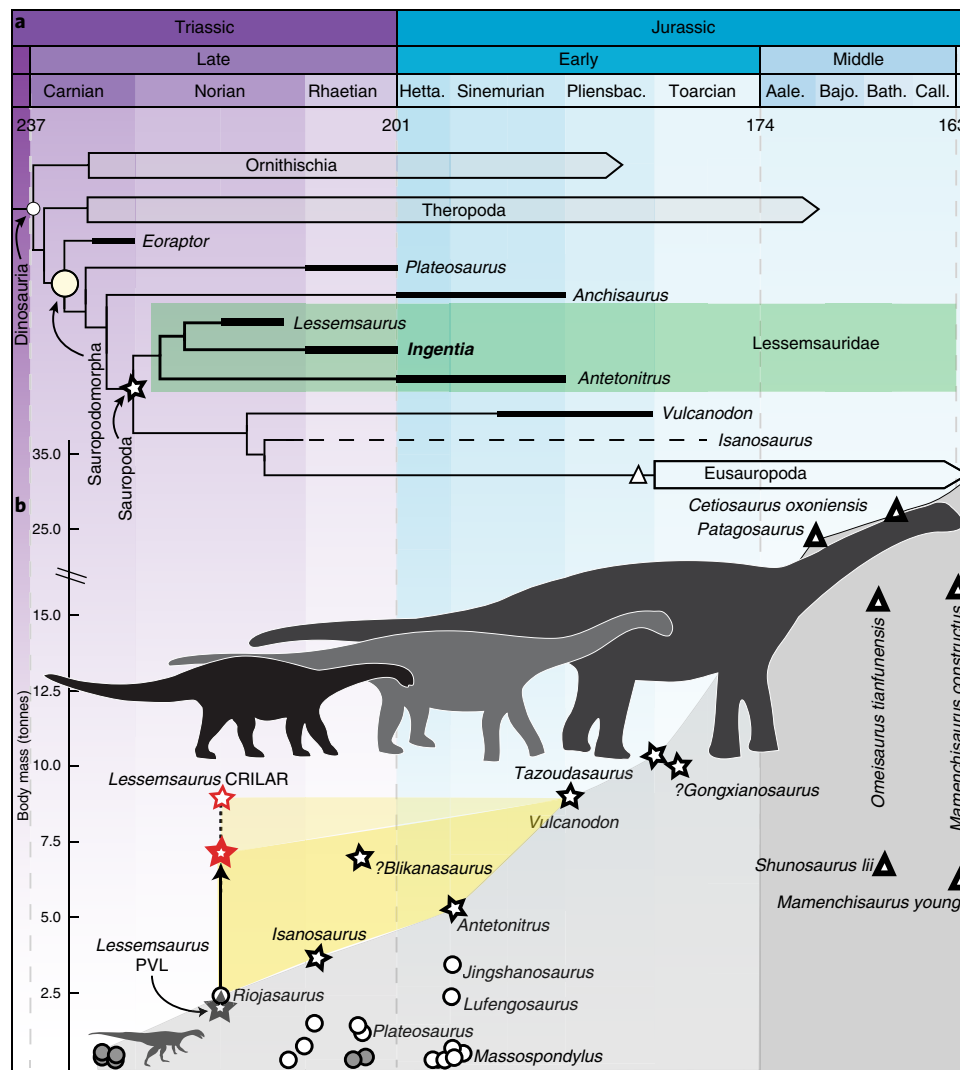


Fig. 3 | Origin of Sauropoda and its relationship with the evolution of the body mass. a, Phylogenetic relationships of Lessemsauridae within a simplified tree of Sauropodomorpha obtained from the dataset of Cerda et al.³⁶ (Methods and Supplementary Information). Numbers indicate Ma. **b**, Evolution of body mass among Sauropodomorpha during the Late Triassic and Early-to-Mid Jurassic. Grey circles represent the most basal sauropodomorphs, white circles the non-sauropod sauropodomorphs, stars the non-eusauropod sauropodomorphs (red stars, *Lessemsaurus*) and triangles the eusauropods. Body masses are from Benson et al.¹⁷, with the addition of some non-eusauropod sauropodomorph taxa^{13,45} (Supplementary Table 2). Body mass for *Lessemsaurus* was estimated by linear regression of iliac measurements versus body mass (thick red star), and by direct comparison of the dimensions and proportions of each bone element versus body mass (thin red star; see Supplementary Information). Silhouettes indicate general morphotypes acquired by Sauropodomorpha from the Late Triassic to the Late Jurassic. Aale., Aalenian; Bajo., Bajocian; Bath., Bathonian; Call., Callovian; Hetta., Hettangian; Pliensbac., Pliensbachian.

eusauropods^{15,40,41}. The pneumatic structures present in the cervical vertebrae of *Ingentia* and *Lessemsaurus*, and in the dorsal vertebrae of *Antetonitrus*^{27,31}, suggest the presence of an avian-like respiratory system in lessemsaurids that was more developed in terms of invading the axial skeleton than in basal sauropodomorphs. In contrast with eusauropods, in lessemsaurids the cervical and abdominal air sacs probably only invaded the neural arches^{27,42} (that is, not the vertebral centra) (Supplementary Figs. 4 and 5). Moreover, lessemsaurids also lacked an elongated neck as they had proportionately short cervical vertebrae, indicating that the neck elongation was not a prerequisite for achieving body sizes comparable to those of basal eusauropods or gravisaurians (see Supplementary Information).

The upright position of the limbs has been highlighted as a major feature of the sauropodomorph bauplan that is considered an adaptation to gigantism^{13,15,18,20,25}. Lessemsaurids have a pectoral girdle and forelimb anatomy like that of early sauropodomorphs,

with the posteroventral orientation of the scapular glenoid precluding an erect posture of the humerus and a completely pronated manus^{13,25,30,31,43,44}, together with a relative flexed forelimb posture (flexor fossa of the distal humerus, shallow radial fossae and developed olecranon of the proximal ulna, and twisted digit I)^{29–31,44}. Similarly, sauropodomorph plesiomorphies in the ilium, such as the reduced preacetabular process or the presence of brevis fossa, which determined the length and orientation of associated muscles (*m. iliotibialis* and *m. caudofemoralis brevis*^{13,18,45}), differed from the modified features of giant eusauropods (see Supplementary Information). Thus, lessemsaurids lacked the purported adaptations related to a fully erect forelimb and the marked modifications of the hindlimb lever arms in eusauropods, showing that these features were not strictly necessary for the acquisition of gigantic body size. The aforementioned eusauropod features may instead be more related to the evolution of graviportalism rather than body size.

However, lessemsaurids have sauropod-derived femoral traits—a fourth trochanter at the midshaft, ovoid in cross-section, and a tibia-to-femur ratio <0.7 (refs ^{29–31})—traditionally correlated with a slow but powerful hindlimb stride in response to increasing body mass^{13,45,46} (see Supplementary Information). Additionally, the apomorphic vertebral anatomy of lessemsaurids with remarkably tall neural arches and a high postzygapophyseal level indicate an enlarged epaxial musculature that strengthened the axial skeleton in relation to forces that held the neck at a low-to-horizontal angle^{24,25}. The mosaic of derived and plesiomorphic traits in the skeleton of lessemsaurids highlights these derived femoral and vertebral features that may represent some of the key skeletal innovations related to the acquisition of large body masses in lessemsaurids.

In the Late Triassic, Lessemsauridae achieved body sizes comparable to those of the Early Jurassic basal gravisaurians and eusauropods while maintaining a plesiomorphic body plan through a novel growth strategy of cyclical and remarkably high growth rates. Pneumatic cervical and dorsal neural arches indicating an avian-like invasion of the axial skeleton by the respiratory system, few muscle- and leverage-related modifications, including high neural arches and an apomorphic femur, and elongated proportions of the forelimb (ulna/humerus) and hindlimb elements (tibia/femur) probably represented key elements in the mosaic of features that allowed the first pulse of gigantism in dinosaurs during the Triassic. However, this unique growth strategy and body plan of lessemsaurids continued only up to the Early Jurassic when the most recent members are recorded⁴⁷, after which the eusauropod growth strategy and biomechanical design prevailed among Sauropodomorpha to subsequently evolve into the largest land animals in the history of life.

Methods

Histology. Appendicular bones of the four lessemsaurid individuals belonging to two different taxa (*Lessemsaurus* and *Ingentia prima* nov. gen. et sp.) were used in this study, including one humerus of *Ingentia* (PVSJ 1086), and two scapulae (PVL 4822/5 and CRILAR PV-303) and two femora (PVL 4822/64 and PVL 6580) of *Lessemsaurus*. The transverse thin sections from the humerus and femur PVL 4822/64 were generated from the midshaft. The cross-section of the femur PVL 6580 was obtained from a more distal portion shaft. In the case of the scapulae, incomplete transverse sections from the ventral side of the mid portion of the elements were obtained. To ensure no loss of gross morphological data, the elements were moulded before thin sectioning, and resin casts were made. Specimens were prepared for thin sections based on the methodology outlined in Chinsamy and Raath⁴⁸. The preparation of the histological sections was carried out at the Egidio Feruglio Museum of Trelew (Argentina) and the Departamento de Geología de la Universidad Nacional de San Luis (Argentina). All histological specimens were analysed using a petrographic polarizing microscope (LabKlass and Nikon E200 Pol). The nomenclature and definitions of structures used in this study are derived from Francillon-Vieillot et al.⁴⁹ and de Ricqlès et al.⁵⁰.

Phylogenetic analysis. To know the phylogenetic relationships of the new species *Ingentia prima*, we scored the new anatomical and histological information throughout the last version of the Sauropodomorpha matrix³⁶ originally published by Yates et al.³⁵. Some multistate characters were ordered (characters 8, 13, 19, 23, 40, 57, 69, 92, 102, 108, 117, 121, 134, 144, 147, 149, 150, 157, 167, 170, 171, 177, 205, 207, 222, 227, 242, 251, 254, 277, 294, 299, 336, 342, 349, 353 and 370). The modified dataset of 372 phylogenetic characters and 62 taxa was analysed under equally weighted parsimony in TNT⁵¹, using a heuristic search of 100 replicates of Wagner trees (with random addition sequence) followed by tree bisection and reconnection branch swapping. Node supports were calculated using decay indexes (Bremer support) and absolute GC bootstrap frequencies calculated after 10,000 pseudoreplicates. To evaluate the causes of the polytomy and those related taxa, we compared pruned trees to obtain a reduced consensus tree⁵², and causes of instability were assessed applying iterative PCR⁵³ to the data matrix. The phylogenetic nomenclature follows the definitions proposed by Sereno⁵⁴ for Sauropodomorpha and Sauropodiformes, Yates³⁵ for Sauropoda, Allain and Aquesbi³⁴ for Gravisauria, and Upchurch et al.¹⁰ for Eusauropoda.

Reporting Summary. Further information on experimental design is available in the Nature Research Reporting Summary linked to this article.

Data availability. Data have been deposited in ZooBank under Life Science Identifier urn:lsid:zoobank.org:act:BA79ADBD-3838-4135-96EA-379A9635C9BB

(for the new family) and urn:lsid:zoobank.org:act:D2115835-0084-468F-A555-882FAA3CE2E6 (for the new genus and species). The authors declare that all other data supporting the findings of this study are available within the paper and its Supplementary Information.

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Author contributions

R.N.M. and O.A. designed the research project and conducted the fieldwork. C.A., R.N.M. and D.P. designed the manuscript and described the materials. I.A.C. conducted the histological analyses. C.A. and D.P. conducted the phylogenetic analyses. All authors wrote the manuscript.

Competing interests

The authors declare no competing interests.

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Study description	The study is mainly based in the description of a new species of dinosaur from the Late Triassic of Argentina. It have implied a phylogenetic analysis and comparisons with relative taxa. Some anatomical features (pneumaticity and histological growth) were analyzed with more detail, which revealed novel adaptations and strategies of growth among primitive dinosaurs.
Research sample	The sample consists in a uncompleted specimen (postcranial disarticulated bones) of dinosaur (PVSJ 1086).
Sampling strategy	The new specimen was collected in 2015 during a fieldwork of two weeks, carried out by the researcher team of the Instituto y Museo de Ciencias Naturales, Universidad Nacional de San Juan.
Data collection	The data collection (morphological features observed in the new specimen) were translated to the morphological data set (Mesquite matrix) in the LAB period of work.
Timing and spatial scale	N/A - The data collection was produced on Lab, immediately after the mechanical preparation of the specimen.
Data exclusions	Data was not excluded.
Reproducibility	No reproducible experiments were carried out.
Randomization	The randomization is not a method used to evaluate new fossil species of vertebrates.
Blinding	Blinding is not part of the design nor methods used for the discovery and study of vertebrate fossils.
Did the study involve field work?	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No

Field work, collection and transport

Field conditions	The fieldwork was carried out on a desertic zone of Northwestern Argentina (Marayes - El Carrizal Basin)
Location	Marayes Basin is located at Northwestern of Argentina, precisely at Southeastern of San Juan Province.
Access and import/export	To access to the basin is possible by National routes 150, of San Juan Province (Caucete town)
Disturbance	No disturb was caused by this study.

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Palaeontology

Specimen provenance	The new species described here comes from Marayes Basin (Quebrada del Barro Formation), at northwestern of Argentina (South America).
Specimen deposition	The specimens are deposited in the palaeovertebrate collection of the Isntituto y Museo de Ciencias Naturales, Universidad Nacional de San Juan (PVSJ).
Dating methods	The new species was collected in 2015 during a fieldwork, it was studied by comparison with other known species, and it was assigned a new scientific name based on its morphological features.

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