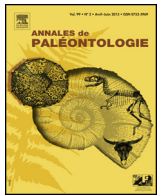




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Original article

New record of ornithopod dinosaur from the Plottier Formation (Upper Cretaceous), Patagonia, Argentina



Nouvelle occurrence de dinosaure ornithopode de la Formation Plottier (Crétacé Supérieur), Patagonie, Argentine

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ABSTRACT

Ornithopods are the least known dinosaurs within the Upper Cretaceous record of Argentina. For this reason every new record is very important to know their evolution in South America. Here, we describe a new remain of an indeterminate ornithopod recovered in the *Petrobrasaurus* quarry of the Puesto Hernández area, northeastern Neuquén province (Argentina), late Coniacian–early Santonian in age. MAU-Pv-PH-458 is the northernmost bone record of an ornithopod in Argentina. This is a fragmentary neural arch from the middle section of the dorsal series of similar size to *Macrogryphosaurus gondwanicus*. MAU-Pv-PH-458 has typical ornithopod characters such as a lateromedial narrow neural spine and transverse processes dorsoposteriorly to posteriorly oriented. It shares with *Macrogryphosaurus* the presence of a deep channel between the bases of the postzygapophysis, which is a continuation of the channel that separates the postzygapophyses in posterior view. MAU-Pv-PH-458 increases the ornithopod record from the Plottier Formation.

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R É S U M É

La présence de dinosaures ornithopodes dans le Crétacé supérieur est encore peu documentée en Argentine. Chaque nouvelle découverte est très importante pour connaître l'évolution de ce groupe en Amérique du Sud. Nous décrivons ici de nouveaux restes fossiles d'un ornithopode indéterminé trouvés dans la carrière à *Petrobrasaurus* de la localité Puesto Hernández, dans le Coniacien supérieur–Santonien inférieur de la partie Nord-Est de la province de Neuquén (Argentine). MAU-Pv-PH-458 est le matériel ostéologique d'ornithopode découvert le plus au Nord en Argentine. Il s'agit d'un arc neural fragmentaire provenant de la partie moyenne de la série vertébrale dorsale et dont la taille est similaire à celle de *Macrogryphosaurus gondwanicus*. MAU-Pv-PH-458 montre des caractères typiques d'ornithopode, tels qu'une épine neurale latéro-médialement étroite, des processus transverses orientés dorso-postérieurement à postérieurement, entre autres. Il partage avec *Macrogryphosaurus* la présence d'un profond sillon entre la base des postzygapophyses, qui est la continuité du sillon séparant les postzygapophyses en vue postérieure. MAU-Pv-PH-458 augmente la liste des découvertes d'ornithopodes de la Formation Plottier.

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1. Introduction

The fossil record of Ornithopoda from the Upper Cretaceous of Argentina *plus* Antarctica is sparse at a low taxonomic level compared with that of other dinosaurs (Coria and Cambiaso, 2007; Rozadilla et al., 2016). Seven different species are identified: *Gasparinisaura cincosaltensis* Coria and Salgado, 1996b, *Notohypsilophodon comodorensis* Martínez, 1998, *Anabisetia saldiviai* Coria and Calvo, 2002, *Talenkauen santacrucensis* Novas et al., 2004, *Macrogryphosaurus gondwanicus* Calvo et al., 2007, *Trinisaura santamartaensis* Coria et al., 2013, and *Morrosaurus antarcticus* Rozadilla et al., 2016 (see Table 1), and abundant fragmentary remains diagnosable only to high taxonomic level. The fragmentary character of these remains, the shortage of anatomic elements similar or diagnostic complicates the comparison between taxa and, therefore, studies on paleobiodiversity.

We present a fragmentary dorsal neural arch of an ornithopod (MAU-Pv-PH-458) from the Puesto Hernández fossil site (Filippi

et al., 2011; Fig. 1). In this area, there are exposed outcrops belonging to the Plottier Formation (late Coniacian–early Santonian) of the Río Neuquén Subgroup. In this quarry, the titanosaur sauropod *Petrobrasaurus puestohernandezii* Filippi et al., 2011, and two different types of theropod teeth (Canudo et al., 2009; Filippi et al., 2011) were previously described. The record of dinosaur remains from the Plottier Formation is scarce, being composed from the remains previously mentioned *plus* several remains from other localities of the Neuquén and Río Negro provinces. In the Neuquén province, dinosaur bones have been found in the Aguada del Caño locality (the huge titanosaur “*Antarctosaurus giganteus*”, undetermined titanosaur and theropod dinosaurs; Von Huene, 1929) and in the Narambuena site (an indeterminate Aeolosaurini, Filippi et al., 2013). In the Río Negro province, vestiges of dinosaurs have been localized in the El Anfiteatro area: several fragmentary remains of titanosaurs, carcharodontosaurids, unenlagiids, indeterminate coelurosaurids and theropods, and a pedal ungual phalanx of an indeterminate ornithopod, the only other bone of an

Table 1
Cretaceous ornithopod record from Argentina.
Occurrences d'ornithopodes crétacés d'Argentine.

Locality	Taxon	Current status	Age	Stratigraphic unit	References
Río Negro province Cinco saltos	<i>Gasparinisaura cincosaltensis</i>	<i>Gasparinisaura cincosaltensis</i>	Santonian–early Campanian	Anacleto Fm., Río Colorado subgroup, Neuquén Group	Coria and Salgado (1996b) Salgado et al. (1997) Coria (1999) Dingus et al. (2000) Coria and Cambiaso (2007) Salgado et al. (2009)
El Anfiteatro	Ornithopoda indet.	Ornithopoda indet.	Late Coniacian–late Santonian	Plottier Fm., Río Neuquén subgroup, Neuquén Group	Coria and Calvo (2002)
Neuquén province Cerro Bayo Mesa	<i>Anabisetia saldiviai</i>	<i>Anabisetia saldivia</i>	Turonian	Cerro Lisandro Fm., Río Neuquén subgroup, Neuquén Group	Calvo et al. (2007)
Southwestern coast of Mari Menuco lake	<i>Macrogryphosaurus gondwanicus</i>	<i>Macrogryphosaurus gondwanicus</i>	Middle–late Coniacian	Sierra Barrosa Fm., Río Neuquén subgroup, Neuquén Group	Coria and Cambiaso (2007)
Bandera Hill	Iguanodontia indet.	Iguanodontia indet.	Coniacian	Portezuelo Fm., Río Neuquén Subgroup, Neuquén Group	Coria et al. (2004) Coria et al. (2007)
Plaza Huincul	Iguanodontia indet.	Iguanodontia indet.	Cenomanian	Huincul Fm. (ACG pers. obs.), Río Limay Subgroup, Neuquén Group	Porfiri and Calvo (2002) Calvo and Porfiri (2003)
Northern coast of Los Barreales lake	Iguanodontia indet.	Iguanodontia indet.	Coniacian	Portezuelo Fm., Río Neuquén subgroup, Neuquén Group	Canudo et al. (2013)
Agrio del Medio	Ornithopoda indet.	Ornithopoda indet.	Late Cenomanian–Turonian	Huincul Fm., Río Limay subgroup, Neuquén Group	This paper
Puesto Hernández quarry, Rincón de los Sauces	Ornithopoda indet.	Ornithopoda indet.	Late Coniacian–late Santonian	Plottier Fm., Río Neuquén subgroup, Neuquén Group	Martínez (1998) Lamanna et al. (2003) Ibircu et al. (2014) Ibircu et al. (2010)
Chubut province Neighboring of Buen Pasto, Chubut province	<i>Notohypsilophodon comodorensis</i>	<i>Notohypsilophodon comodorensis</i>	Middle Cenomanian–Turonian	Bajo Barreal Fm., Chubut Group	Novas et al. (2004)
Southeastern of the Colhué Huapi lake	Ornithopoda indet.	Ornithopoda indet.	Middle Cenomanian–Turonian	Bajo Barreal Fm., Upper Member	Ameghino (1899) Molnar (1980) Coria and Salgado (1996a) Coria and Cambiaso (2007)
Santa Cruz province Los Hornos Hill, Argentino lake	<i>Talenkauen santacrucensis</i>	<i>Talenkauen santacrucensis</i>	Maastrichtian	Pari Aike Fm.	Ameghino (1899) Molnar (1980) Coria and Salgado (1996a) Coria and Cambiaso (2007)
Pair-Aike	“ <i>Loncosaurus argentinus</i> ”	Ornithopoda indet.	Cenomanian–Santonian	Mata Amarilla Fm.	Ameghino (1899) Molnar (1980) Coria and Salgado (1996a) Coria and Cambiaso (2007)
Antartica Santa Marta Cove, James Ross Island	<i>Trinisaura santamartaensis</i>	<i>Trinisaura santamartaensis</i>	Upper Campanian	Snow Hill Island Fm.	Coria et al. (2013)
El Morro Peninsula, James Ross Island	<i>Morrosaurus antarcticus</i>	<i>Morrosaurus antarcticus</i>	Maastrichtian	López de Bertodano Fm.	Rozadilla et al. (2016)
Vega Island	A basla euornithopoda indet.	A basal euornithopoda indet.	Maastrichtian	López de Bertodano Fm.	Hooker et al. (1991) Coria et al. (2013) Coria et al. (2007) Coria et al. (2013)
Santa Marta Cove, James Ross Island, Antarctica	Ornithopoda indet.	Ornithopoda indet.	Upper Campanian	Snow Hill Island Fm.	Hooker et al. (1991) Coria et al. (2013) Coria et al. (2007) Coria et al. (2013)

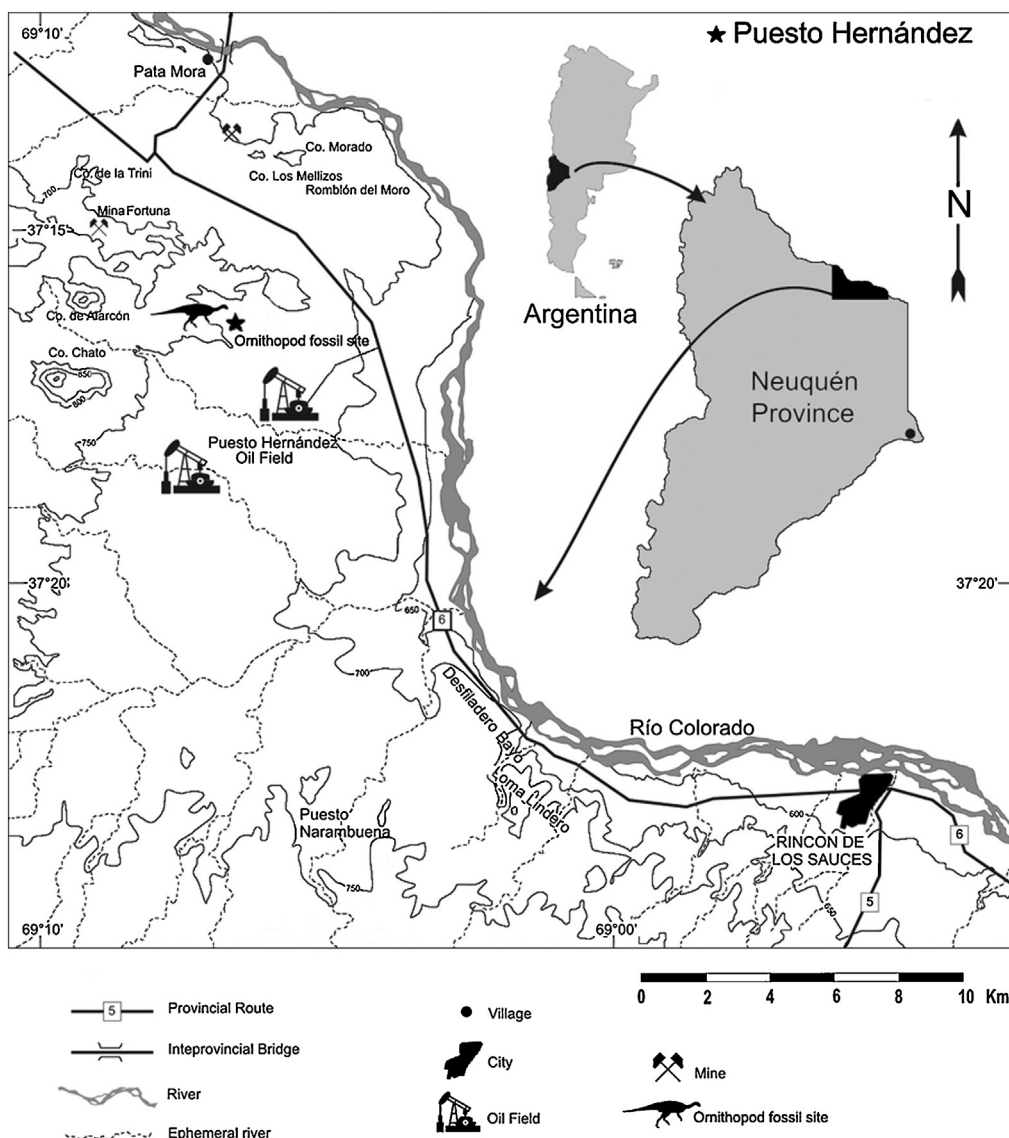


Fig. 1. Location map of Puesto Hernández (Neuquén, Patagonia, Argentina).
Carte de localisation de Puesto Hernández (Neuquén, Patagonie, Argentine).

indeterminate ornithopod from the Plottier Formation, (Salgado et al., 2009). In this context, the new material MAU-Pv-PH-458, although very fragmentary, is important, because it is the northernmost record of a South American ornithopod and the second bone in the Plottier Formation from the Neuquén province.

The main goals of the present paper are:

- to describe the first dorsal neural arch of an ornithopod from the Plottier Formation for the Neuquén province;
- to compare the osteology with the other Argentinean *plus* Antarctic ones;
- to provide new insights into the paleobiodiversity and paleobiogeography of the ornithopods in Argentina.

Institutional abbreviations: MAU-Pv-PH: Museo Argentino Urquiza – Paleontología de Vertebrados – Puesto Hernández.

2. Geological setting

Specimen MAU-PV-PH-458 was recovered from the lower part of the Plottier Formation (Río Neuquén Subgroup, Neuquén Group),

with an estimated age situated into later Coniacian–early Santonian (Garrido, 2010). Although this unit is not exposed their base at the study area, field observations corroborated that its lower limit would be located no more than 12 m below the bottom of the profile represented on Fig. 2.

The deposits of the fossil site have been characterized by Filippi et al. (2011) as fluvial deposits linked to sandy braided channel systems. The fossil-bearing levels comprise a 2.5 m thick fill channel deposits, composed mainly by quartzolitic, coarse to medium-grained sandstones with develop of sets of planar cross-stratification and low angle cross-stratification. Laterally, horizontal stratification is also developed. The identification in this level of downstream-accretion macroforms (*sensu* Miall, 1996), allows to assign these deposits to longitudinal or mid-channel sandy bars.

The base of the body exhibits a strong erosive contact, followed by small lens (minor 10 cm thick) formed by coarse lithic granules and abundant muddy intraclasts. Precisely, one of these lenses yields the piece under study, such deposits were linked to scour and fill deposits (lithofacies Ss, *sensu* Miall, 1996). Along the outcrop, this type of deposits yields abundant teeth and isolated small

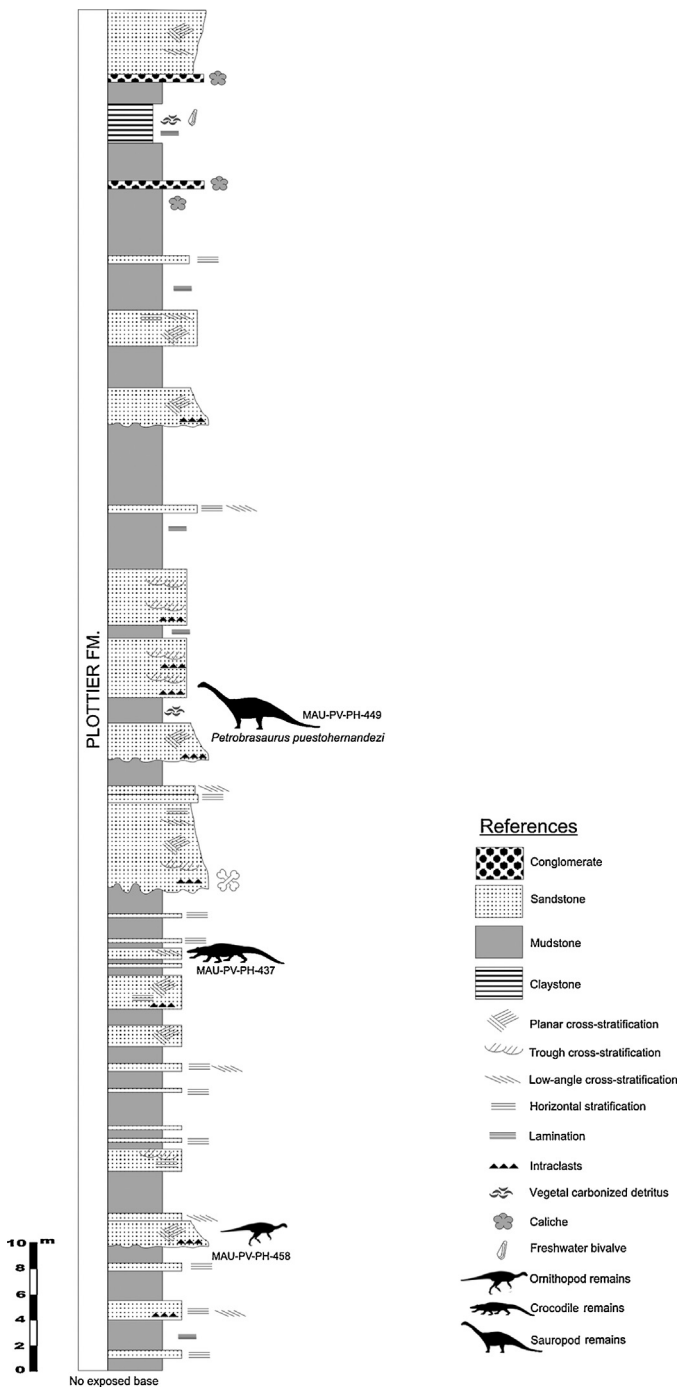


Fig. 2. Lithostratigraphic section of the Plottier Formation in Puesto Hernández site. Coupe lithostratigraphique de la Formation Plottier à la localité Puesto Hernández.

bone pieces, besides exhibiting strong abrasion, which suggest a prolonged action transport and subsequent deposition as bottom, channel-lag deposits.

3. Systematic paleontology

Dinosauria Owen, 1842
Ornithischia Seeley, 1887
Ornithopoda Marsh, 1881

Ornithopoda indet.

Material: a partial dorsal neural arch (MAU-Pv-PH-458).

Horizon and locality: late Coniacian–early Santonian, Plottier Formation (Río Neuquén Subgroup, Neuquén Group, Neuquén Basin; Garrido, 2010). Puesto Hernández Oil field area, 25 km north-west of the Rincón de los Sauces city, Neuquén province, Patagonia, Argentina.

4. Description and comparison

MAU-Pv-PH-458 is a fragmentary mid-dorsal neural arch (Fig. 3A–C). This specimen displays typical characters of Ornithopoda, such as a lateromedially narrow neural spine, dorsoposteriorly to posteriorly addressed transverse process, articular surface of the prezygapophyses mediolaterally inclined, and articular surfaces of the postzygapophyses laterally inclined (Norman et al., 2004). The neural arch shows a fracture surface in the area of contact with the centrum. This fracture may reflect osteological maturity (Horner and Currie, 1994), as it occurs in other reptile groups, but it cannot be definitely stated without an osteohistological analysis (Irmis, 2007). Its size (lateromedial width: 91.44 mm, anteroposterior length: 66.97 mm, and dorsoventral height: 57.73 mm) is similar to the dorsal vertebrae of *Macrogyphosaurus*, indicating it belongs to an ornithopod distinct from smaller taxa such as *Gasparinisaura*, *Notohypsilophodon*, *Anabisetia* or *Trinisaura* (Fig. 3; Coria and Salgado, 1996b; Martínez, 1998; Coria and Calvo, 2002; Calvo et al., 2007; Coria et al., 2013).

MAU-Pv-PH-458 has preserved the base of the neural spine, both transverse processes, which are almost complete, both prezygapophyses, which are complete, and the base of both postzygapophyses. The neural spine is narrow lateromedially and wide anteroposteriorly. The transverse processes are slightly dorsoposteriorly directed and wider anteroposteriorly than dorsoventrally, as in other ornithopods (Norman et al., 2004). On the ventral side, there is a strong lateromedial ridge with two concave areas, anterior and posterior to the base of the ridge. The anterior concave area is wider and deeper than the posterior one. The prezygapophyses are longer anteroposteriorly than wide lateromedially, with a quadrangular articular face. They face inwardly, upwardly, and a little forwardly. The neural spine does not reach the base of this channel, staying up to the anterior border of the transverse processes. In dorsal view, close to the base of the prezygapophysis, there is a shallow concavity. The base of the postzygapophysis is separated by a deep and closed channel. Their articular surfaces are broken but were apparently laterally inclined. The area under the postzygapophysis is broken, in view of which the existence of a hyposphene could not be corroborated in MAU-Pv-PH-458. This area shows the continuation of the deep channel that separates the base of the two postzygapophyses. This channel is very similar to that observed in the 13th dorsal vertebra of *Macrogyphosaurus* (Calvo et al., 2007; Fig. 3F and G). The neural arch is more circular and wider than in *Macrogyphosaurus* (Fig. 3D and E).

5. Discussion and paleobiogeography

The morphology of MAU-Pv-PH-458 is similar to that observed in other dorsal neural arches of ornithopod dinosaurs (Norman et al., 2004). Due to its fragmentary condition and the fact that the dorsal vertebrae of ornithopods do not have autapomorphies that permit a specific taxonomic assignment, MAU-Pv-PH-458 is referred to an indeterminate ornithopod. According to its size and compared with the ornithopod record from Argentina plus Antarctica, MAU-Pv-PH-458 belongs to an indeterminate ornithopod of almost 6 meter long, similar to *Macrogyphosaurus* and slightly larger than *Talenkauen* and *Morrosaurus* (Novas et al., 2004; Calvo et al., 2007; Rozadilla et al., 2016).

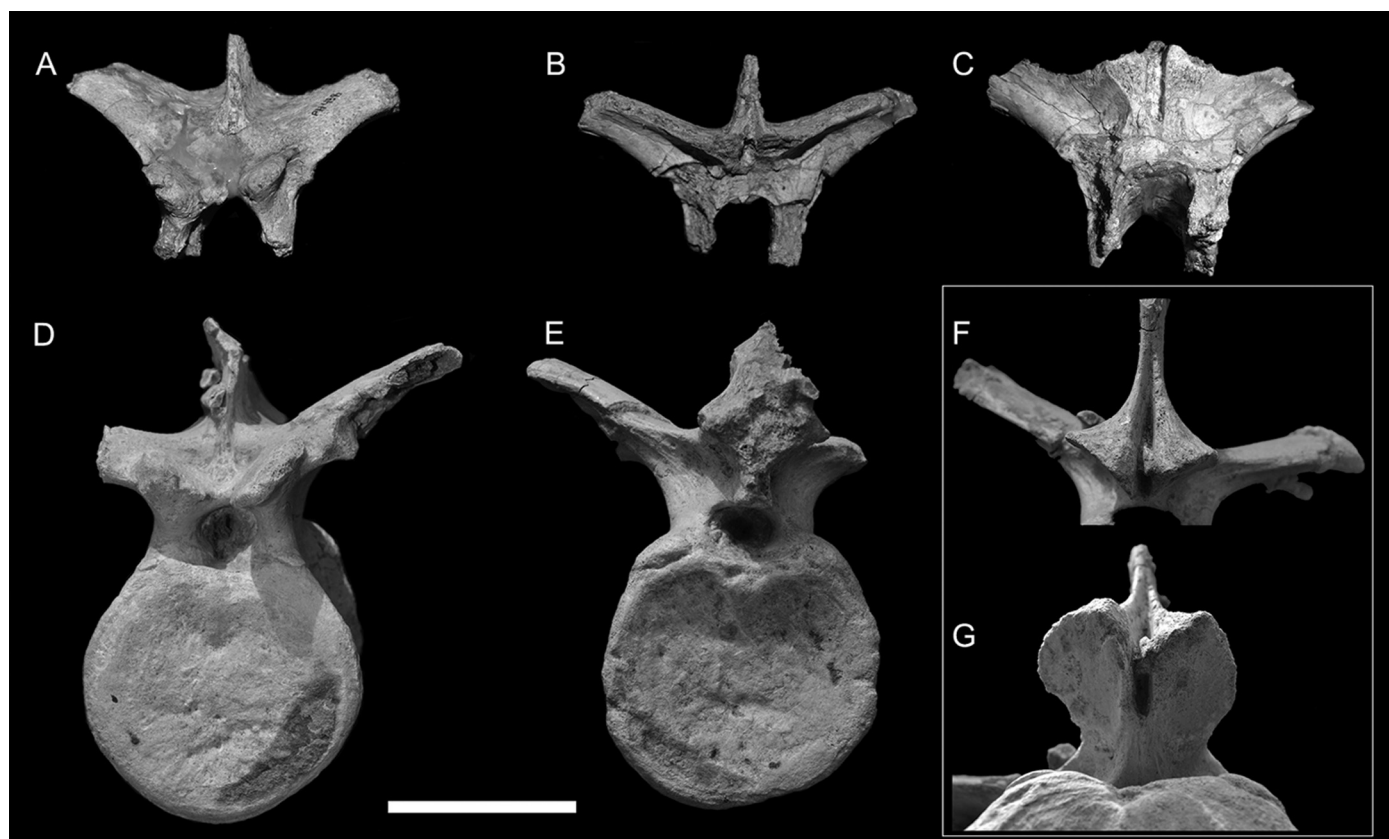


Fig. 3. Dorsal vertebral neural arches: A–C, Ornithopoda indet., MAU-Pv-PH-458; D–G, *Macrogyryphosaurus gondwanicus*, MUCPv-321; D–E, 14th dorsal vertebra and F–G, detail of 13th dorsal vertebra. A and D in anterior view; B, E and F in posterior view, and C and G in ventral view. Scale: 5 cm.

Arcs neurales de vertèbres dorsales: A–C, *Ornithopoda indet.*, MAU-Pv-PH-458; D–G, *Macrogyryphosaurus gondwanicus*, MUCPv-321; D–E, 14^e vertèbre dorsale et F–G, détail de la 13^e vertèbre dorsale. A et D en vue antérieure; B, E et F en vue postérieure, et C et G en vue ventrale.

MAU-Pv-PH-458 is part of a rich South American ornithopod record from Cenomanian to the Maastrichtian. The remains have assignment taxonomic to high level and specific level with seven species described. This record is distributed along all Patagonian provinces plus Antarctica having at least one species for province (see Table 1). In the Coniacian–Santonian interval, the highest diversity of ornithopod remains is observed in the Neuquén province. MAU-Pv-PH-458 coincides stratigraphically and geographically with *Macrogyryphosaurus* (also from the Neuquén Province) and only in time interval with *Gasparinisaura* and *Notohypsilophodon* (from Río Negro and Chubut provinces, respectively). Outside South America, MAU-Pv-PH-458 is contemporary with the two Asian taxa *Haya griva* Makovicky et al. (2011) and *Koreanosaurus boseongensis* Huh et al. (2011) and the European taxon *Rhabdodon* Matheron, 1868–1869. According to Boyd (2015), these Asian taxa belong to clade Parkosauridae, like the Argentinian clade Elasmaria (*Macrogyryphosaurus*, *Notohypsilophodon* and *Talenkauen*). According to this same author, South American ornithopod taxa were product of two migratory pulses: a first one from Australia (possibly via Antarctica) and a second one from Asia through North America. The diversification of the taxa of the second migratory pulse gave rise to the clade Elasmaria and also probably to the ornithopods located in northern Patagonia, from which MAU-Pv-PH-458 is originated.

6. Conclusions

The discovery of MAU-Pv-PH-458 increases the knowledge about temporal and spatial distribution of medium/large-sized ornithopods in the Upper Cretaceous of Argentina plus Antarctica

(see Table 1). The fossil record indicates that the Upper Cretaceous ornithopods were widely distributed throughout Argentina and Antarctica, and that they formed a rich biota.

Finally, MAU-Pv-PH-458 adds a new record of Ornithopoda to the Plottier Formation, up to now consisting only in a pedal ungual phalanx from El Anfiteatro area (Río Negro province). On this context, MAU-Pv-PH-458 is the northernmost record of a South American ornithopod, the second record of an ornithopod in the Plottier Formation, and the first of this unit in the Neuquén province. Thus, the known distribution range of this clade of dinosaurs during the Coniacian–early Santonian is extended. Future study of this formation in this area and the acquisition of new material would be of great interest to the poor knowledge of the ornithopods of this period, and will improve our understanding of this fauna in Argentina.

Disclosure of interest

The authors declare that they have no competing interest.

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