

**NOTOHYPSILOPHODON COMODORENSIS GEN. ET SP. NOV. A
HYPSILOPHODONTIDAE (ORNITHISCHIA: ORNITHOPODA) FROM THE
UPPER CRETACEOUS OF CHUBUT, CENTRAL PATAGONIA, ARGENTINA¹**

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ORIGINAL ENGLISH ABSTRACT (Grammar edited): The ornithopod dinosaur *Notohypsilophodon comodorensis* gen. et sp. nov. is described. Only one specimen was discovered in strata of the Bajo Barreal Formation from the Upper Cretaceous (Cenomanian ?) of southern Chubut, Argentina. *Notohypsilophodon* shares with other Hypsilophodontidae the following femoral features: presence of an ischiatic groove, an anterior trochanter well below the greater trochanter, a shallow intertrochanteric cleft and the absence of an extensor groove in the distal end; besides this, there is a caudal flexure of the humerus at the level of the deltopectoral region. There is not any iguanodontian feature in the remains of this Patagonian ornithopod. *Notohypsilophodon* is diagnosed by a humerus without a deltopectoral crest, tibia with an anteromedial bulge, fibula abruptly narrowed at the distal middle of the shaft, astragalus with proximal surface in two levels, calcaneum with a strong posterodistal projection and ungual phalanges with flat ventral surfaces. *Notohypsilophodon* is considered the first Hypsilophodontidae recorded in South America.
Key words: Hypsilophodontidae-Cretaceous-Patagonia

Introduction

The investigation projects “The vertebrates of the Bajo Barreal Formation, Upper Cretaceous of Chubut” and “The vertebrates of the Chubut Group: characteristics and evolution-first stage” have been developed successively by the Laboratorio de Paleovertebrados of the UNPSJB in Comodoro Rivadavia since the year 1985. During their course a rich fauna of vertebrates from the Bajo Barreal Formation has been documented that includes holostean fish, chelonians, crocodiles, abelisaurian and tetanuran theropod dinosaurs, and titanosaur and diplodociform sauropods. To this fauna is added the ornithopod that is the subject of this work. The record of ornithischian dinosaurs in South America has been scarce until recent times, and it includes *Pisanosaurus mertii* (Casamiquela, 1967) from the Triassic of La Rioja and the Upper Cretaceous hadrosaurs of Patagonia, such as the Chubutian *Secernosaurus koernerii* (Brett-Surman, 1979) that probably comes from the Bajo Barreal Formation. Recent and important ornithischian discoveries in the region of Comahue, in the north of Patagonia, include the basal iguanodont *Gasparinisaura cincosaltensis* (Coria and Salgado, 1996) and other ornithopods now in study. Recently, Salgado and Coria (1996) have studied a proximal piece of femur originally classified as belonging to a theropod, *Loncosaurus argentinus* (Ameghino, 1898) and have considered it an indeterminate ornithopod. This work describes *Notohypsilophodon comodorensis*, new genus and species, considered

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here as the first Hypsilophodontidae (Sues and Norman, 1990) from South America. The material comes from the Bajo Barreal Formation, belonging to the Chubut Group. The age of the Chubut Group is controversial although there is major agreement in assigning it to the Upper Cretaceous: Senonian (Huene, 1929; Sciutto and Martínez, 1994), Maastrichtian (Menéndez, 1959); Senonian-pre-Maastrichtian (Bonaparte and Gasparini, 1979). Older ages have been suggested by Lesta and Ferello (Valanginian - lower Senonian, 1972) and Lesta et al. (Barremian-Campanian, 1980). The faunal assemblage documented to the present in the Bajo Barreal Formation, especially the sauropods, indicates a possible Cenomanian age to the author. The Chubut Group is constituted, from older to more modern, by the Matasiete (Aptian), Castillo, Bajo Barreal and Laguna Palacios (Upper Cretaceous) formations (Sciutto and Martínez, 1994).

ABBREVIATIONS: UNPSJB-Pv = Universidad Nacional de la Patagonia “San Juan Bosco” – Paleovertebrados.

Systematic Paleontology:

ORNITHISCHIA Seeley, 1888

ORNITHOPODA Marsh, 1871

HYPSILOPHODONTIDAE Dollo, 1882

Notohypsilophodon gen. nov.

Notohypsilophodon comodorensis gen. et sp. nov.

Derivatio nominis: From the Greek “noto” southern; “hypsos” high; “lophos”, crest; “odous”, tooth.

Type species: *Notohypsilophodon comodorensis* sp. nov.

Diagnosis: Humerus without deltopectoral crest, tibia with an anteromedial enlargement in the proximal end, fibula with an abrupt narrowing in the shin, astragalus with the proximal surface displaced in two levels, calcaneum with a marked posterodistal projection, and ungual phalanges of the foot with flat ventral surfaces.

Notohypsilophodon comodorensis sp. nov.

HOLOTYPE: UNPSJB-PV 942, a partial skeleton that includes vertebrae (4 cervical, 7 dorsal, 4 sacral, and 6 caudal), fragments of 4 ribs, left scapula (incomplete), right coracoid, right humerus, both ulnae, left femur (incomplete), right tibia, left tibia (incomplete), left fibula, right fibula (incomplete), right astragalus, left calcaneum, and 13 pedal phalanges (3 unguals).

TYPE LOCALITY: 28 kilometers to the NE of the town of Buen Pasto, in south-central Chubut Province, central Patagonia, Argentina (Fig. 1).

HORIZON: Bajo Barreal Formation, upper part of the lower member (J. Sciutto, pers. comm.); Upper Cretaceous (Cenomanian?).

DIAGNOSIS: The same as that of the genus.

Derivatio nominis: in reference to the city of Comodoro Rivadavia, the first in Patagonia to sustain a fossil vertebrate investigation team.

Description

The genera *Lesothosaurus* (Galton, 1978), *Thescelosaurus* (Gilmore, 1913), *Othnielia* (Galton, 1977), *Fulgurotherium* (Huene, 1932), *Yandusaurus* (He, 1979), *Hypsilophodon* (Huxley, 1869), *Tenontosaurus* (Ostrom, 1970), *Dryosaurus* (Marsh, 1894), *Valdosaurus* (Galton, 1977), *Gasparinisaura* (Coria and Salgado, 1996b) and *Kangnasaurus* (Haughton, 1915) have been used for comparison.

Vertebral Column

Four cervical vertebrae have been preserved, of which only two conserve part of the neural arch. The centra are amphiplatyan as in *Yandusaurus*. The middle cervicals (Fig. 2) have an anterior articular surface of pentagonal contour with the vertex located ventrally; the posterior articular face is semicircular. The ventral keel and the parapophyses are similar to those of other hypsilophodontids. The prezygapophyses are strongly projected and have large and rounded articular sides as in *Hypsilophodon* and *Yandusaurus*. The suture between the neural arch and the centrum is very marked. The neural spine seems to have been weak. The neural canal is very large. The dorsal vertebrae have smoothly amphicoelous centra, with the form of an hourglass and longitudinal rugosities in their ventral articular borders; only one preserves the neural arch (Fig. 3), where it is observed that the diapophyses were proportionally long and at their base, posteriorly, there is a wide hollow. The prezygapophyses are rounded and large and the neural spine is weak. The sacral vertebrae (Fig. 4, a and b) are similar to those of other hypsilophodontids, with wide, lengthened, and amphiplatyan centra, and with very well marked ventral intervertebral sutures. 5 sacral vertebrae in two groups of 3 fused anterior vertebrae and 2 more posterior vertebrae, also fused, respectively, have been preserved. In the first group there are remains of neural arches and of the last neural spine that is anteroposteriorly lengthened and laterally compressed. Part of the second sacral rib of the right side has been preserved that is very thick, more so than in *Hypsilophodon* or *Dryosaurus*. The caudal vertebrae have somewhat amphicoelous centra and they stand out in their possession of a characteristic longitudinal ventral furrow (Fig. 5) as in *Gasparinisaura*, at least in the anterior caudals. In the anterior and posterior ventral articular borders smooth articular surfaces for the haemal arches are observed. None of the caudals preserves the neural arch. The proximal extremes of 4 ribs have been preserved, similar to those of other hypsilophodontids. Ossified tendons associated with *Notohypsilophodon* have not been found.

Pectoral Girdle And Forelimb

Almost the entire proximal end of the left scapula (Fig. 6 a and b) has been conserved, except for the acromial process and the distal part of the blade. The bone is curved in dorsal view, with the external side convex and the medial concave. The surface to articulate with the coracoid, that is proportionally much larger than the surface for the glenoid cavity, stands out in the proximal end. Laterally, between the glenoid and coracoid articular surfaces, there is a strong notch more marked than those existing in

Lesothosaurus, *Thescelosaurus*, or *Othnielia*, and similar to that present in juveniles of *Tenontosaurus* (Forster, 1990). The almost complete right coracoid (Fig. 7) is oval as in *Hypsilophodon* and *Gasparinisaura*, and has articular characteristics similar to those of the scapula. The lateral surface is smoothly convex and the medial is concave. The semilunar notch, located posteriorly under the glenoid cavity, seems to be smaller than that present in *Hypsilophodon* and *Othnielia*, but similar to that present in *Yandusaurus*.

The coracoid foramen is large. The humerus (Fig. 8) is a slender piece, and curved in anterior view as in that of *Yandusaurus multidens*. The ends are little expanded and they lack torsion between them. Proximally the humerus lacks the wide anterior depression present in *Yandusaurus* and *Dryosaurus* (Galton, 1981) and, as a prominent feature, does not have a deltopectoral crest and only possesses weak longitudinal rugosities for muscular insertion in that area. In basal Ornithischia, Hypsilophodontidae, Iguanodontia, and Hadrosauridae, a very marked deltopectoral crest exists. The humeral head has a marked middle posterior tuberosity, as in *Dryosaurus*. The distal end has an anteroposteriorly expanded radial condyle and a rounded ulnar condyle as in *Yandusaurus*. Anteriorly there is a delicate intercondylar depression, differing from *Lesothosaurus*, *Dryosaurus*, and *Yandusaurus*. The posterior groove is very marked. At the level of the deltopectoral area, medially and laterally, a smooth caudal flexion of the humerus is observed, like the one mentioned by Weishampel and Heinrich (1992) for Hypsilophodontidae.

The ulna (Fig. 9) is a slender bone, very similar to that of *Hypsilophodon*, with its ends slightly twisted; the proximal end is triangular, with a weak olecranon. The proximal half of the ulna is smoothly concave in medial view and convex laterally. In medial view there is a light intercondyloid depression in the moderate distal expansion.

Hindlimb

The left femur (Fig. 10 a and b) is represented by its proximal and distal extremes. Proximally, the femoral head is bulbous and there is a very marked neck between it and the greater trochanter. This last is much larger than the anterior trochanter (it occupies three fourths of the trochanteric region), much more than in *Othnielia*, *Dryosaurus*, and *Gasparinisaura* and similar to that of *Hypsilophodon*. The anterior trochanter does not reach the level of the greater trochanter as in *Yandusaurus*, *Othnielia*, and the Australian Hypsilophodontidae *Fulgurotherium* and Victorian hypsilophodontid types 1 and 3 (Rich and Rich, 1989). The intertrochanteric fissure is delicate as in *Hypsilophodon*, *Fulgurotherium*, and Victorian hypsilophodontids 1 and 3. In the base of the anterior trochanter there is a small enlargement that is a probable point of insertion for the M. iliofemoralis (Galton, 1969). In medial view, the femoral head has a smooth furrow that extends from the posterior to the anterior surface. In posterior view, the femoral head has, obliquely, a very marked ischiatic canal as in *Hypsilophodon*. Galton (1974) points out that this structure is a depression related to the ischiatic pedicel of the ilium. The distal end of the femur is notable for its lack of an anterior intercondylar furrow as in *Hypsilophodon*, *Yandusaurus*, *Othnielia*, *Fulgurotherium*, Victorian hypsilophodontid

type 1, and *Gasparinisaura*. The medial condyle is well developed and the lateral seems to have been small. The posterior flexor canal is well developed.

The tibia (Fig. 11 a and b) is a straight bone with the proximal end more expanded than the distal. As in *Dryosaurus* the cnemial crest is small, smoothly laterally and proximally directed, and the external condyle is robust. There is a marked anteromedial longitudinal enlargement in the proximal third of the bone; this does not exist in *Lesothosaurus*, *Thescelosaurus*, *Othnielia*, *Hypsilophodon*, *Yandusaurus*, and *Gasparinisaura*. In *Dryosaurus* this enlargement is insinuated but without the development reached in the Patagonian dinosaur. The distal end is triangular, with the external malleolus larger and projected more distally than the internal malleolus. Anteriorly there is a wide notch related to the articulation of the ascending process of the astragalus. This notch is similar to that of *Thescelosaurus* and *Yandusaurus* and different from the small notch of *Dryosaurus*. In distal view, the posterior angle of the tibia has a depression to receive the posterior part of the astragalus, that is much less defined than in *Dryosaurus*.

The fibula (Fig. 12) is a slender bone, of sigmoid contour in medial view, and that presents an abrupt anteroposterior narrowing in half of the shin that continues toward the distal extreme; on the other hand in *Lesothosaurus*, Hypsilophodontidae, Iguanodontia, and Hadrosauridae, the fibula is a bone more or less straight and regular in lateral view. The proximal end is well expanded and in medial view there is a triangular depression that becomes a flat surface at the half of the bone. The posterior angle of the proximal end is projected more proximally than the anterior angle. The distal expansion is modest and in distal view it has a semicircular contour, with the flat side in anterior view.

The incomplete astragalus (Fig. 13) is a roughly square piece, convex in distal view and concave in proximal view. The medial border is semilunar and the lateral is broken. In anterior view the small triangular ascending process stands out, similar to that of the Hypsilophodontidae. In proximal view the articular surface is situated at two levels separated by a marked difference or “step” that limits the wide surface for the internal malleolus of the tibia and the smaller, strongly concave surface for the external malleolus: this last contacts with the calcaneum and is at a level markedly lower than the medial area. In *Thescelosaurus* the proximal surface of the astragalus is divided into a high and wide sector for the internal malleolus of the tibia and a smaller area in a slightly lower level for the external malleolus; in Hypsilophodontidae, Iguanodontia, and Hadrosauridae a similar situation exists. Such a marked difference as that existing in the astragalus of *Notohypsilophodon* seems to be exclusive to the Patagonian form.

The calcaneum (Fig. 14) is a smoothly concave element in lateral view, with an edge limiting its borders. In medial view the smooth posterior oblique surface for the external malleolus of the tibia and the robust tubercle for the astragalus stand out. In proximal view the facet to articulate with the fibula is strongly concave. Distally the surface is convex with some rugosities. The most outstanding feature of the calcaneum is a marked posterodistal projection related to an amplification of the surface for the external malleolus of the tibia. This strong projection does not exist in *Thescelosaurus*,

Hypsilophodon, *Yandusaurus*, *Othnielia*, and *Tenontosaurus*, is insinuated in *Dryosaurus*, and well developed in *Kangnasaurus*.

13 phalanges belonging to the feet of *Notohypsilophodon* have been recovered. One of the proximal phalanges (Fig. 15) possesses a concave articular surface for a metatarsal and a distal articulation with two almost symmetrical condyles that have a medial depression and another lateral one, respectively. The intercondylar canal is very marked. One of the middle phalanges is proportionally short, with the proximal articular surface divided by a sagittal crest that defines two concavities. Also in proximal view the dorsal and ventral articular borders are projected proximally forming, overall dorsally, two very marked protuberances. The ungual phalanges (Fig. 16) are triangular in dorsal view and have poorly defined articular facets proximally. Laterally the grooves for the claws are well developed. The ventral surface of the ungual phalanges is flat, contrary to the curvature present in *Lesothosaurus*, *Hypsilophodon*, *Othnielia*, *Yandusaurus*, *Tenontosaurus*, *Dryosaurus*, and more derived iguanodonts.

Age of the Individual

The holotype of *Notohypsilophodon* seems to have pertained to a juvenile individual since the neural arches and the vertebral centra are not fused, an immature feature according to Galton (1982), besides, the humerus does not show signs of torsion between its ends, a juvenile characteristic from Sternberg (1940).

Discussion

Regrettably the remains of *Notohypsilophodon comodorensis* do not include the skull, which would have been very important for the determination of the relationships of this dinosaur within Ornithopoda. However, the good preservation of diverse postcranial material allows one to locate *Notohypsilophodon* within the family Hypsilophodontidae. The proximal end of the femur of the Chubutian ornithopod has a small anterior trochanter located at an level lower than that of the greater trochanter, as in *Othnielia*, *Fulgorotherium*, Victorian hypsilophodontid type 1, and *Yandusaurus*. In *Hypsilophodon* and iguanodonts like *Tenontosaurus*, *Dryosaurus*, *Valdosaurus* (Galton and Taquet, 1982) and others, this trochanter reaches the level of the greater trochanter. The ischiatic canal existing in the posterior face of the femoral head of *Notohypsilophodon* is very marked, as in *Hypsilophodon*, while in the iguanodonts *Tenontosaurus*, *Dryosaurus*, *Valdosaurus*, and *Gasparinisaura* it is very little developed. In the distal end of the femur of *Notohypsilophodon* an anterior intercondylar groove does not exist, as in Hypsilophodontidae and exceptionally in *Gasparinisaura*; conversely the iguanodonts *Tenontosaurus*, *Dryosaurus*, *Valdosaurus*, and others more derived have it, very markedly. Weishampel and Heinrich (1992) point out that the existence of a caudal flexure of the humerus at the level of the deltopectoral crest is a characteristic of *Yandusaurus*, *Othnielia*, *Hypsilophodon*, *Orodromeus*, and *Tenontosaurus*; on the other hand in *Heterodontosaurus*, *Camptosaurus*, and *Dryosaurus* the caudal border is primitively straight. Also in the iguanodont *Gasparinisaura* the caudal border is straight, while in *Notohypsilophodon* the smooth humeral flexion exists. In contrast to this

combination of characters of *Notohypsilophodon*, shared with ornithopods commonly designated as Hypsilophodontidae, such as *Othnielia*, *Hypsilophodon*, *Fulgurotherium*, and *Yandusaurus* (Rich and Rich, 1989; Sereno, 1986; Weishampel and Heinrich, 1992), characteristic features of Iguanodontia are not observed in the material of the Chubutian dinosaur.

Notohypsilophodon comodorensis constitutes the first hypsilophodontid registered in South America and it adds, next to *Gasparinisaura cincosaltensis* and other new Iguanodontia discovered in Río Negro and Neuquén, to the growing number of ornithopods recorded in Argentina, discoveries that speak in favor of long and varied evolutionary development in South America, more than of a late migration from the Northern Hemisphere.

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Cited Bibliography see original publication

Figure Captions

FIGURE 1: Map showing the location of the locality where *Notohypsilophodon comodorensis* was found.

FIGURE 2: Cervical vertebra of *Notohypsilophodon comodorensis* (UNPSJB-Pv 942, holotype) in anterior view. Abbreviations: E. N., neural spine; O. N., neural canal; P., parapophysis; PRZ., prezygapophysis.

FIGURE 3: Dorsal vertebra of *Notohypsilophodon comodorensis* (UNPSJB-Pv 942, holotype) in dorsal view. Abbreviations: D., diapophysis; E., neural spine; PRZ., prezygapophysis.

FIGURE 4: Sacral vertebrae of *Notohypsilophodon comodorensis* (UNPSJB-Pv 942, holotype) in posteriorial (a) and ventral (b) views. Abbreviations: C. S., sacral rib; E. N., neural spine; S. I., intervertebral suture.

FIGURE 5: Caudal vertebral centrum of *Notohypsilophodon comodorensis* (UNPSJB-Pv 942, holotype) in ventral view. Abbreviation: S. V., ventral sulcus.

FIGURE 6: Left scapula of *Notohypsilophodon comodorensis* (UNPSJB-Pv 942, holotype) in posterioral (a) and ventral (b) views. Abbreviations: C. G., surface of the glenoid cavity; S. C., articular surface for the coracoid.

FIGURE 7: Right coracoid of *Notohypsilophodon comodorensis* (UNPSJB-Pv 942, holotype) in posterioral view. Abbreviations: A. E., scapular articulation; C. G., glenoid cavity; F. C., coracoid foramen.

FIGURE 8: Right humerus of *Notohypsilophodon comodorensis* (UNPSJB-Pv 942, holotype) in anterior view. Abbreviations: D. I., intercondylar depression; R. D. P., deltopectoral rugosities.

FIGURE 9: Left ulna of *Notohypsilophodon comodorensis* (UNPSJB-Pv 942, holotype) in medial view. Abbreviation: O., olecranon.

FIGURE 10: Left femur of *Notohypsilophodon comodorensis* (UNPSJB-Pv 942, holotype), a) proximal and distal ends in posterior (A), posterioral (B), and anterior (C) views and b) in distal view. Abbreviations: C. F., femoral head; C. I., ischiatic canal; C. M., medial condyle; T. A., anterior trochanter; T. M., greater trochanter.

FIGURE 11: Right tibia of *Notohypsilophodon comodorensis* (UNPSJB-Pv 942, holotype) in anterior (a) and posterior (b) views. Abbreviations: A. A., articulation for astragalus; C. C., cnemial crest; M. E., external malleolus; M. I., internal malleolus.

FIGURE 12: Left fibula of *Notohypsilophodon comodorensis* (UNPSJB-Pv 942, holotype) in medial view. Abbreviation: medial cavity.

FIGURE 13: Right astragalus of *Notohypsilophodon comodorensis* (UNPSJB-Pv 942, holotype) in proximal view. Abbreviations: P. A., ascending process; S. M. E., surface for the external malleolus of the tibia; S. M. I., surface for the internal malleolus.

FIGURE 14: Left calcaneum of *Notohypsilophodon comodorensis* (UNPSJB-Pv 942, holotype) in posterioral view. Abbreviations: S. F., surface for the fibula; S. T., surface for the tibia.

FIGURE 15: Proximal pedal phalanx of *Notohypsilophodon comodorensis* (UNPSJB-Pv 942, holotype) in posterioral view. Abbreviation: D. A., articular facet.

FIGURE 16: Pedal ungual phalanx of *Notohypsilophodon comodorensis* (UNPSJB-Pv 942, holotype) in posterioral view. Abbreviations: F. A., articular facet; S. L., posterioral groove.