Dermal spines of stegosaurian dinosaurs from the Lower Cretaceous (Hauterivian-Barremian) of Galve (Teruel, Aragón, Spain)

Espinas dérmicas de dinosaurios estegosaurios en el Cretácico Inferior (Hauteriviense-Barremiense) de Galve (Teruel, Aragón, España)

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RESUMEN

Se describen restos de dinosaurios estegosaurios en el Cretácico Inferior (facies «Weald») de la región de Galve (Teruel). El material consiste en dos espinas dérmicas aisladas: una espina pequeña y delgada procedente de la localidad de La Canaleta (Formación El Castellar, Hauteriviense terminal) y la base de una robusta espina caudal del yacimiento de Barranco Espina (Formación Camarillas, Barremiense inferior). Los fósiles descubiertos en Galve se asignan a Stegosauria indet. y son los primeros elementos dermatoesqueléticos de estegosaurios (y de tireóforos) descritos en Aragón. Además, las espinas de Galve son unos de los escasos restos de estegosaurios descubiertos en el Cretácico Inferior de Europa y del mundo.

Key words: Stegosauria, armour, Early Cretaceous, Wealden Beds, Iberian Peninsula.

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Introduction

Stegosaurs are ornithischian dinosaurs characterized mainly by two parasagittal rows of osteoderms consisting of a combination of plates and spines (Galton, 1990; Galton and Upchurch, 2004). The earliest possible record consists of two incomplete columnar femoral shafts from Aust Cliff, England (Upper Triassic, Rhaetian; Galton, 2005), definitive skeletal remains are known from the Middle Jurassic to possibly the Late Cretaceous, but they are best represented in the Late Jurassic (Galton and Upchurch, 2004); stegosaurs are poorly documented in the Early Cretaceous (only four or five species are known), but their remains have been described from beds of this age in Europe, Africa, Asia, South America and, with doubts, in Australia (Pereda Suberbiola *et al.*, 2003; Galton and Upchurch, 2004). In Europe, only one taxon is currently recognized from the Wealden beds of England: *Craterosaurus pottonensis* Seeley, 1874 from the Aptian strata (reworked from ?Valanginian or Barremian) of Bedfordshire (Galton, 1981; Galton and Upchurch, 2004). *Regnosaurus northamptoni* Mantell, 1848 from the Valanginian of Sussex, the first stegosaurian material to be described, is now regarded as a *nomen dubium* (Barrett and Upchurch, 1995; Galton and Upchurch, 2004). Some dermal bones from the Wealden beds of the Isle of Wight (Barremian) and Hastings (Valanginian or Hauterivian) have been assigned to ?Stegosauria *incertae sedis* by Blows (2001).

Stegosaurian material from the Early Cretaceous of the Iberian Peninsula is rather scarce and indeterminate at the generic or species level (Pereda Suberbiola and Galton, 2001). It includes a few vertebrae and dermal elements from the Hauterivian-Barremian of Aldea del Pinar, near Salas de los Infantes, Burgos (Pereda Suberbiola *et al.*, 2003) and, provisionally, vertebral remains from the late Barremian-basal Aptian of Castellote, Teruel (Ruiz-Omeñaca, 2000). Other stegosaurian remains that have been reported from the basalmost Cretaceous or, more probably, the uppermost Jurassic (Purbeck beds) of the Iberian Peninsula consist of a dorsal plate, a tail spine and a partial rib of an indeterminate stegosaur found near Lourinhã in Estremadura, Portugal (Galton, 1994; Pereda Suberbiola and Galton, 2001) and postcranial remains, including cervical, dorsal and caudal vertebrae, ribs, an ischium, a femur and a tail spine referred to *Dacentrurus armatus* from Alpuente, Valencia (Casanovas *et al.*, 1995a, 1995b, 1999).

Here we describe new stegosaurian remains from the Lower Cretaceous of the Galve region (Teruel). The fossils were collected by the local amateur palaeontologist J.M. Herrero and are now in the collection of the Museo Paleontológico de Galve (MPG).

Systematic palaeontology

Ornithischia Seeley, 1888
Thyreophora Nopcsa, 1915
Stegosauria Marsh, 1877
Stegosauria indet.

Provenance.

La Canaleta, Galve, Teruel; lower part of the El Castellar Formation, Lower Cretaceous, uppermost Hauterivian (Canudo *et al.*, 1997; Ruiz-Omeñaca *et al.*, 2004) (Fig. 1).

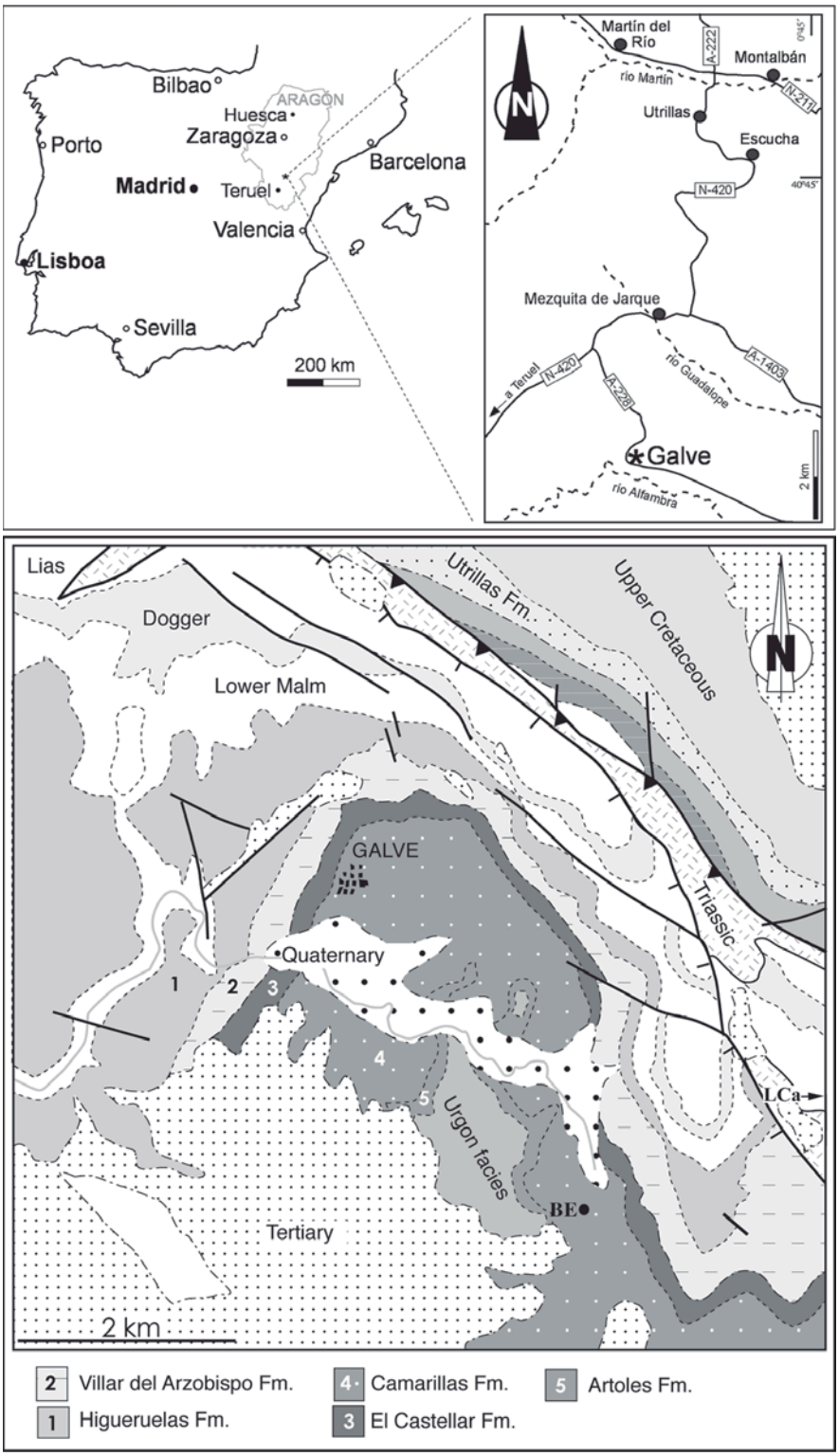

Fig. 1.- Geological map showing the stegosaurian localities of Galve (Teruel): BE, Barranco Espina; LCa, La Canaleta. Modified from Ruiz-Omeñaca *et al.* (2004).

Fig. 1.- Situación geográfica y geológica de los yacimientos con estegosaurios de Galve (Teruel): BE, Barranco Espina; LCa, La Canaleta. Modificado de Ruiz-Omeñaca* et al. *(2004).

Description.

MPG/LCa-1 (Figs. 2A-B) is a small and slender spine lacking the base and apex; it is 275 mm long and the proximal widths are 63 mm anteroposteriorly by 51 mm transversely. The broken proximal end is oval in cross-section and only slightly expanded, mainly on the anterior face. Several longitudinal grooves run along the bone surface but there are no sharp edges.

Discussion.

The spine from La Canaleta is similar to some of the tail spines of *Stegosaurus* (Ostrom and McIntosh, 1966: pl. 55; McWhinney *et al.*, 2001: fig. 7D) and *Hesperosaurus* (Carpenter *et al.*, 2001: fig. 3.13G) because of its slenderness and in probably having a small base. In these spines the total length is four to five times the maximum basal length. However, the Galve spine is only about a half to a third the size of the North American ones. The Galve spine is comparable in size to a tail spine of *Dacentrurus* from the Late Jurassic of Portugal (Galton, 1991: figs. 8A-C) and slightly larger than a referred tail spine of *Lexovisaurus* from the Middle Jurassic of England (Galton, 1985: figs. 18R-S). However, it differs from the former in the oval proximal cross section and from the latter in having rounded edges. Comparisons with stegosaurian taxa from the Early Cretaceous of Europe are not possible because *Craterosaurus pottonensis* is based on a neural arch of a dorsal vertebra (Galton, 1981) and *«Regnosaurus northamptoni»* on a partial dentary (Barrett and Upchurch, 1995).

Provenance.

Barranco Espina, Galve, Teruel; Camarillas Formation, Lower Cretaceous, lower Barremian (Canudo *et al.*, 1997; Ruiz-Omeñaca *et al.*, 2004) (Fig. 1).

Description.

Only the basal region of the massive spine MPG/BE-1 is preserved (Figs. 2C-E). The spine has an obliquely inclined base in lateral or medial view (Fig. 2C). The base is expanded, with a maximum length of 115 mm and a maximum width of 110 m. The nearly flat base is broad and oval to subtriangular in shape, the surface is coarsely textured, and the anterior edge is wider than the posterior one (Fig. 2E). The anterior border of the spine has a thick, sharp edge (Fig. 2D) and, to a lesser extent, so does the posterior one. The asymmetry in anterior view (Fig. 2D) indicates that it may be from the right side. The bone surface of the spine itself is only moderately sculptured.

Discussion.

Blows (2001) outlines the problems involved in discriminating between isolated dermal spines of stegosaurs and those of 'polacanthid' ankylosaurian thyreophorans. Based on specimens from the Lower Cretaceous deposits of southern England, he suggested several characters to separate the stegosaurian armour from their ankylosaurian equivalent (Blows, 2001). The Galve spine shares with those of stegosaurs a solid, flattened base, straight edges, and rounded and thicker keeled edges. However, the Galve spine base lacks

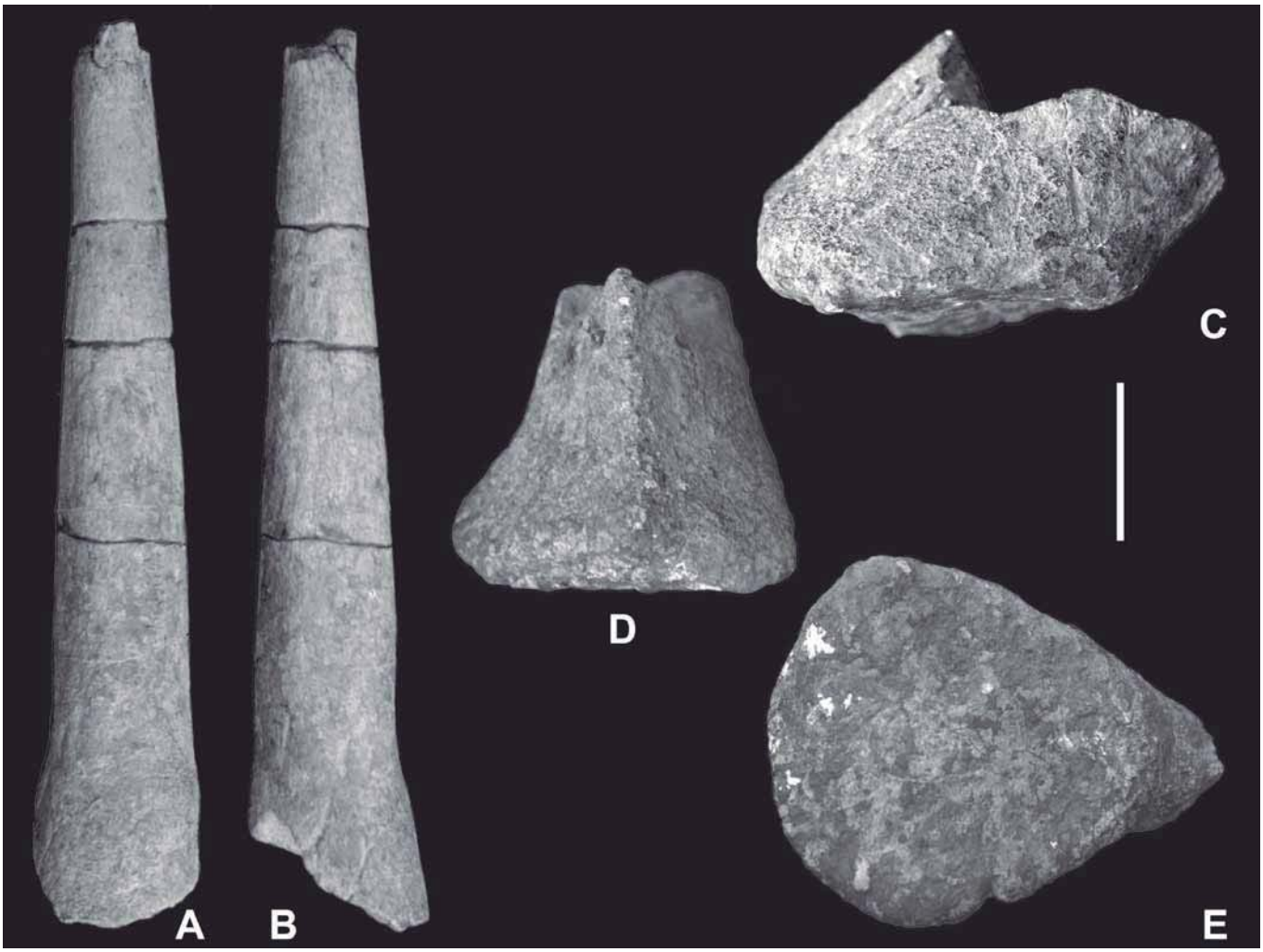

Fig. 2.- Stegosauria indet. dermal armour remains from the Early Cretaceous (Wealden facies) of Galve, Teruel. A-B, MPG/LCa-1, incomplete slender spine in anterior (A) and lateral or medial (B) views, from the El Castellar Formation (uppermost Hauterivian) of La Canaleta; C-E, MPG/BE-1, base of a possibly right massive tail spine in ?medial (C), anterior (D) and ventral (E) views, from the Camarillas Formation (lower Barremian) of Barranco Espina. Scale bar: 5 cm.

Fig. 2.- Restos dérmicos de Stegosauria indet. en el Cretácico Inferior (facies «Weald») de Galve, Teruel. A-B, MPG/LCa-1, espina delgada incompleta en vistas anterior (A) y lateral o medial (B), La Canaleta, Formación El Castellar (Hauteriviense terminal); C-E, MPG/BE-1, base de una espina caudal robusta, posiblemente del lado derecho, en vistas medial? (C), anterior (D) y ventral (E), Barranco Espina, Formación Camarillas (Barremiense inferior). Barra de escala: 5 cm.

the basal longitudinal ridge observed on the caudal spines with a flared base of some stegosaurs, such as *Stegosaurus* (Ostrom and McIntosh, 1966, fig. p. 349; type of *S. sulcatus*), *Dacentrurus* (Galton, 1985, fig. 10M; type of *D.* '*hastiger*' – unknown in spine of type of *D. armatus*, fig. 9H) and *Kentrosaurus* (Galton, 1982, pl. 1, figs. 12-16; stoky tail spines of *K. aethiopicus* – ridge absent in the slender tail spines away from the base of the tail, pl. 1, figs. 17-19, pl. 4, figs. 11, 20-23). Moreover, there is no basal nutrient foramen as occurs in some of the tail spines of stegosaurs (Gilmore, 1914; Ostrom and McIntosh, 1966). The Galve specimen is quite similar in size and in shape to a tail spine from the Purbeck facies of Valencia (Casanovas *et al.*, 1995a: pl. 1), but the latter is ornamented ventrally by numerous grooves and indentations. The presacral spines of *Polacanthus* and closely related ankylosaurs [Polacanthidae sensu Carpenter (2001); but note that Vickaryous *et al*. (2004) regarded this taxon as paraphyletic] generally have less expanded, slightly convex bases, and sharper anterior and posterior keel edges. The caudal plates of 'polacanthids' are clearly different from the Galve spine in that they are very compressed laterally and exhibit deeply hollowed bases (Blows, 1987, 2001; Pereda Suberbiola, 1994). Consequently, the Galve specimen is referred to Stegosauria indet.

Blows (2001) speculated on the possibility that the flat, solid bases of stegosaur spines may indicate a presacral position on the body. Nevertheless, the Galve spine is transversely compressed and shows keeled margins, as occurs typically in tail spines of stegosaurs except *Dacentrurus* (Galton, 1985; Galton and Upchurch, 2004: supplement). The angled base of the spine suggests that it may be from the caudal region and that it projected slightly laterally as well as posterodorsal to the vertebral column.

Conclusion

The spines from the Lower Cretaceous Wealden facies of Galve (Teruel) are the first stegosaurian (and even thyreophoran) armour elements described to date from Aragón. Moreover, the slender spine from the El Castellar Formation of La Canaleta is one of the few stegosaurian remains from the Hauterivian of Europe and from the world (Pereda Suberbiola *et al.*, 2003; Galton and Upchurch, 2004). Other thyreophoran material from the Lower Cretaceous beds of Teruel consists of a few ankylosaur teeth from the uppermost Hauterivian-basal Barremian of Josa

(Canudo *et al.*, 2004) and vertebral remains tentatively assigned to the Stegosauria from the upper Barremian-basal Aptian of Castellote (Ruiz-Omeñaca, 2000). Estes and Sanchiz (1982) described an isolated broken tooth from the Lower Cretaceous of Colladico Blanco (top of the El Castellar Formation, latest Hauterivian to early Barremian in age; Ruiz-Omeñaca *et al.*, 2004) near Galve; they referred it to the Fabrosauridae as *Echinodon* sp. *Echinodon becklesi* OWEN, 1861 is a small ornithischian from the Middle Purbeck Beds (basalmost Cretaceous) of Dorset, England that was regarded as a fabrosaurid (Galton, 1978) but later, based on the presence of referred dermal armor («granicones»), it was referred to the Thyreophora (Galton, 1986; Coombs *et al.*, 1990). New research suggests that *Echinodon* is a basal ornithopod, probably a heterontosaurid (Norman and Barrett, 2002; Galton, 2002) and that the granicones represent dermal «knee pads» of a turtle (Barrett *et al.*, 2002). The Galve tooth referred to *Echinodon* sp. by Estes and Sanchiz (1982) is doubtfully thyreophoran and more probably belong to a heterodontosaurid (Ruiz-Omeñaca and Canudo, 2004). Finally, Royo Gómez (1926 and unpublished manuscript) mentioned postcranial stegosaurian remains, including dermal plates, from the Lower Cretaceous of Morella (Castellón). The dermal plates were not illustrated by Royo Gómez (1926) and they are not in the collection of the Museo Nacional de Ciencias Naturales of Madrid; part of the Morella material in the MNCN collection that was assigned to the Stegosauria by Royo Gómez belongs to a sauropod (Ruiz-Omeñaca *et al.*, 2003).

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