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Plesiosaurus houzeaui DOLLO, 1909 from the Upper Campanian of Ciply (Belgium) and a review of the Upper Cretaceous plesiosaurs from Europe.

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Abstract

The holotype of *Plesiosaurus houzeaui* DOLLO, 1909 consists of plesiosaurian bones, discovered in the Spiennes Chalk (Upper Campanian) of the Ciply area (Mons Basin, Belgium). The description of the type material shows that *Plesiosaurus houzeaui* is an invalid species based on heterogeneous elasmosaurid and also probably non-elasmosaurid plesiosaurian material. A review of plesiosaurian material previously described from the Upper Cretaceous of Europe indicates that Elasmosauridae and Pliosauridae are represented. *Polyptychodon* is the only valid genus of plesiosaur from the Upper Cretaceous of Europe.

Key-words - *Plesiosaurus houzeaui*, Plesiosauria, Upper Cretaceous, Europe, revision.

Résumé

L'holotype de *Plesiosaurus houzeaui* DOLLO, 1909 est une collection d'ossements de plésiosaures découverts dans la Craie de Spiennes (Campanien supérieur) de la région de Ciply (Bassin de Mons, Belgique). La description du matériel-type montre que *Plesiosaurus houzeaui* est une espèce invalide basée sur du matériel hétérogène partiellement attribuable aux Elasmosauridae. Une révision des plésiosaures décrits dans le Crétacé Supérieur d'Europe montre que les Familles des Elasmosauridae et des Pliosauridae sont représentées. *Polyptychodon* est le seul genre valide parmi les plésiosaures du Crétacé Supérieur d'Europe.

Mots-clefs - *Plesiosaurus houzeaui*, Plesiosauria, Crétacé Supérieur, Europe, révison.

Introduction

Plesiosaur remains are frequently found in most stages of the Jurassic of Europe. During the Upper Cretaceous, this group, principally represented by long-necked elasmosaurs, had achieved a worldwide distribution. While most remains come from North America (WELLES, 1962), material has also been reported from South America (CABRERA, 1941; GASPARINI & GONI, 1985), Antarctica (GASPARINI et *al.*, 1984; CHATTERJEE & SMALL, 1989), Russia (ROZHDESTVENSKIY, 1973), Africa (ARAMBOURG, 1952; ANTUNES, 1964), Middle East (DELAIR, 1967; SIGNEUX, 1959), Madagascar (BARDET & TERMIER, 1990), New Zealand (WELLES & GREGG, 1971; WIFFEN & MOISLEY, 1986) and Japan (NAKAYA, 1989). On the other hand, only scant plesiosaur material has been discovered in the Upper Cretaceous of Europe (see discussion).

Marine Cretaceous deposits are well exposed in the Mons Basin (western Belgium). During the second half of the 19th century, the Maastrichtian Ciply Phosphatic Chalk was intensively quarried in this area for manufacture of agricultural fertilizers (LECLERCQ & BOUKO, 1985). Numerous fossil vertebrates were discovered in various quarries, mainly in Ciply. These collections, including fishes, turtles and 52 relatively complete mosasaur skeletons, were transferred to the "Musée royal d'Histoire naturelle" (now, Institut royal des Sciences naturelles de Belgique = IRSNB).

In 1909, DOLLO mentioned the discovery of plesiosaur bones in the Upper Cretaceous of Belgium. He attributed them to the new species *Plesiosaurus houzeaui* without either describing or illustrating them. The study of this material presented in the present paper is also a good opportunity to clarify the systematic status of plesiosaurian material previously described from the Upper Cretaceous of Europe.

Stratigraphic position

The accurate geographical provenance of "*Plesiosaurus houzeaui*" is not known. These bones were discovered in the Spiennes Chalk of the Ciply area (Figure 1), in one of the numerous phosphatic chalk quarries belonging to the firm "Solvay & Cie". Figure 2 shows the stratigraphic succession of the Upper Cretaceous (Campanian and Maastrichtian) in the Mons Basin. The Spiennes Chalk is a white, coarse-grained chalk, with many black flint bands. A thin layer of phosphatised pebbles can be observed at its base. The top becomes arenitic and is capped by a burrowed horizon. The Spiennes Chalk lies upon the Nouvelles Chalk and is overlain by the Ciply Phosphatic Chalk. Both the belemnites and the foraminiferan assemblages indicate an Upper Campanian age (Zone of *Belemnitella "langei"*) for this formation (ROBASZYNSKI & CHRISTENSEN, 1989).

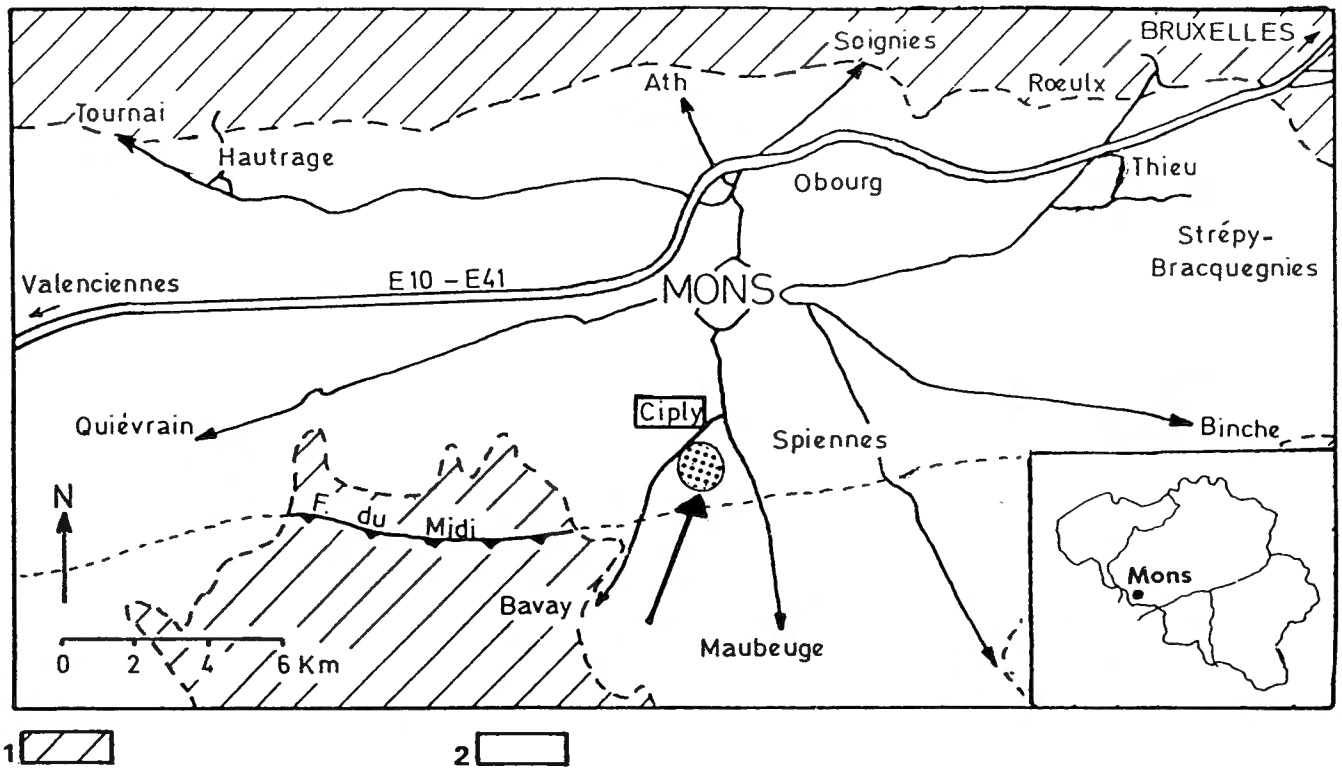


Figure 1 — Geographic location of the Ciply area (indicated by an arrow). After ROBASZYNSKI & CHRISTENSEN, 1989, modified. 1: Palaeozoic basement; 2: Cretaceous marls and chalks.

Description of the material

The material identified by DOLLO as *Plesiosaurus houzeaui* (IRSNB R126) consists of vertebrae, limb bones, an ilium and indeterminate bones. Both the size and the state of preservation of these skeletal elements are so heterogeneous that it is clear that they do not all belong to the same individual (there are, for example, 5 propodial elements). The lack of neural arches fused to the centra implies that they all belong to juvenile (*sensu* BROWN, 1981) individuals.

The measurements taken on the vertebrae of IRSNB R126 are presented in Table 1.

IRSNB R126/1 (Plate 1, Figures A-B) is a greatly eroded anterior cervical centrum. This element is very large and probably belonged to a huge animal. It is quite elongated (L/W = 1.02) and much broader than high (L > W > H). The lateral faces of the centrum bear longitudinal crests. The articular surfaces are dumbbell-shaped.

IRSNB R126/2 is a well preserved anterior cervical centrum: the costal pits, elliptical in shape, are located ventro-laterally on the centrum. This bone is rather elongated (W > L > H; L/W = 0.81). Its ventral surface is concave in the midline and its articular faces are therefore clearly dumbbell-shaped. The longitudinal crests are very pronounced on the lateral faces of the centrum.

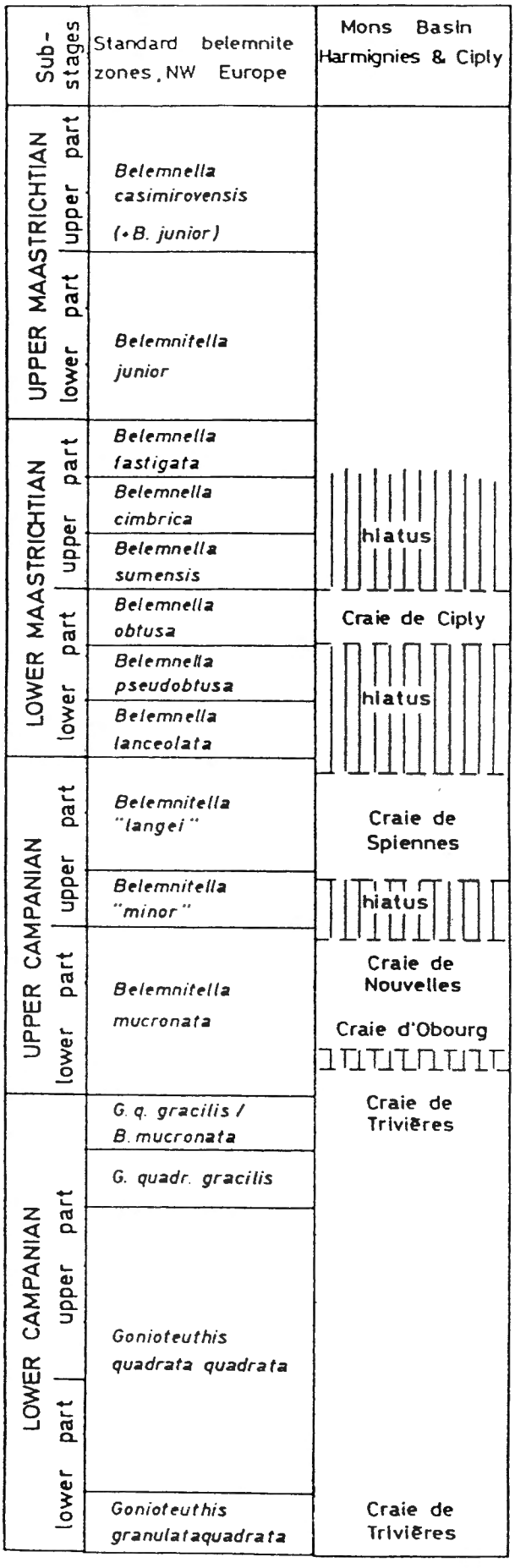
IRSNB R126/2a is a poorly preserved anterior cervical centrum with dumbbell-shaped articular surfaces and an elliptical costal pit.

IRSNB R126/3 (Plate 1, Figures C-D) is a well preserved cervical centrum: the costal pits, ovoid in shape, are located very low on the centrum. Four nutritive foramina can be observed on the ventral face of the bone. This vertebra differs from IRSNB R126/2 by its relative shortness (W > L = H; L/W = 0.66), by the elliptical outline of its articular faces and by the absence of a longitudinal crest on its lateral faces. These characters could indicate a posterior position of this vertebra on the neck.

IRSNB R126/9 is a small well preserved centrum. It is proportionally quite short (L/W = 0.56) and low (W > H > L). The costal facets, located in the middle of the lateral faces, are rounded and very developed. It is therefore regarded as a posterior cervical centrum. The articular faces have an elliptical outline and the lateral surfaces do not bear any longitudinal crest.

IRSNB R126/4 (Plate 1, Figures E-F) is here considered as a pectoral centrum. It is not very elongated (L/W = 0.73) and much wider than high (W > H > L) so that the articular surfaces are elliptical in shape. The costal pits are located high on the lateral faces of the centrum and were probably continued on the neural arch.

IRSNB R126/5-7 (Plate 1, Figures G-H) are dorsal vertebrae of moderate size. Ventral and lateral faces of the centra are regularly convex, without costal insertion facets which were only borne by the transverse processes of the neural arch. These centra are rather elongated (L/W = 0.75-0.78). Their height is slightly less than their width so that their articular faces are almost rounded.



IRSNB R126/5 shows 3 nutritive foramina on its ventral surface.

IRSNB R126/8 is a huge dorsal vertebra in a bad state of preservation. It is rather long (L/W = 0.76) and its articular faces look almost rounded. There is no trace of costal insertion facet on the centrum as usual in dorsal vertebrae.

Table 1 — Measurements (in mm) of the vertebral centra in IRSNB R126.

N°	Length (L)	Width (W)	Height (H)
126/1	129	127	78
126/2	62	77	47
126/3	63	95	64
126/4	66	91	68
126/5	69	90	71
126/6	64	82	68
126/7	54	86	68
126/8	89	119	—
126/9	44	78	56

IRSNB R126/10 (Plate 1, Figure K) is a big, well preserved left(?) propodial. Its prominent but eroded proximal head bears no strong tuberosities. Its expanded distal surface forms two articular faces making an angle of approximately 130°. The anterior distal knee is poorly developed. The bone is much longer than wide and its shaft is rather slender and straight: the distal breadth is estimated to be only 60% of the length (see Table 2).

IRSNB R126/11-14 (Plate 1, Figure L) are small imperfectly preserved propodials. They show a straight shaft and a regularly rounded distal extremity with no clearly defined articular faces. This is probably due to erosion. The posterior edge is more concave than the anterior one.

Table 2 — Measurements (in mm) of the propodials in IRSNB R126. MWPH: maximal width of the proximal head; mWS: minimal width of the shaft; MWDE: maximal width of the distal extremity.

N°	Length	MWPH	mWS	MWDE
126/10	390	?105	100	?250
126/11	178	51	56	103
126/12	—	52	55	—
126/13	—	—	—	?107
126/14	—	—	—	118

IRSNB R126/15-17 (Plate 1, Figures M-O). These mesopodial bones are around 5 cm in longest dimensions.

Figure 2 — Biostratigraphical ages of the Campanian and Maastrichtian formations in the Mons Basin. After ROBASZYNSKI & CHRISTENSEN, 1989, modified.

The largest (IRSNB R126/15) is elliptical in shape and may be a radiale or a tibiale. IRSNB R126/16 (ulnare or fibulare?) and R126/17 (T2?) are respectively hexagonal and rectangular elements.

IRSNB R126/18 (Plate 1, Figure P) is a very stout phalanx or fifth metapodial with a typical hourglass shape.

IRSNB R126/19 (Plate 1, Figure Q). This nearly complete ilium, 25 cm long, shows the typical shape observed in Plesiosauria: a rounded and thick acetabular extremity opposed to a flat vertebral one.

Systematic status of *Plesiosaurus houzeaui* DOLLO, 1909

The type material of *Plesiosaurus houzeaui* DOLLO, 1909 can be shown to consist of heterogeneous plesiosaurian bones discovered in the Upper Cretaceous of the Ciply area. This material includes two cervical vertebrae (IRSNB R126/1 and R126/2) which show indubitable diagnostic characters of the family Elasmosauridae, such as elongated centra bearing a lateral keel and dumbbell-shaped articular surfaces. The low position of the costal pits of IRSNB R126/3 and the absence of longitudinal crest on the lateral surface show that this probably is a posterior cervical vertebra. This centrum does not show elasmosaurian diagnostic characters. IRSNB R126/9 is here tentatively identified as a posterior cervical centrum; it looks proportionally too short for an elasmosaur. The rest of the material, including dorsal vertebrae and limb elements, is not diagnostic of a family: it can only be said that they belong to a Plesiosauria gen. et sp. indet.

Plesiosaurus houzeaui DOLLO, 1909 must therefore be considered as a composite taxon based on elasmosaurid and also probably non-elasmosaurid indeterminable plesiosaurian material.

A review of Upper Cretaceous plesiosaurs from Europe

Upper Cretaceous plesiosaurian remains are rare in Europe. No complete skeleton has been found and the material usually consists of isolated vertebrae, limb bones or teeth (see PERSSON, 1963). Material has been described from England, Belgium, The Netherlands, Germany, Poland, Sweden, Czech Republic and Portugal. Table 3 is a synoptic table of the distribution of Upper Cretaceous plesiosaurians from Europe.

The plesiosaurian remains discovered in England mainly consist of isolated teeth and vertebrae. Among them, only the pliosaur *Polyptychodon* is systematically well defined (see below). Teeth of *Polyptychodon interruptus* OWEN, 1841 have been recorded by MILNER (1987) in the Chalk Marl (Cenomanian) of Cambridgeshire and

Table 3 — Synopsis of the distribution of Upper Cretaceous plesiosaurs in Europe.

FAMILIA PLIOSAURIDAE

Polyptychodon:

— Sussex, Kent, Norfolk and Cambridgeshire (England). Cenomanian to ? Campanian. OWEN, 1851; MILNER, 1987.
— Bavaria (Germany). Cenomanian. MEYER, 1856.
— Bohemia (Czech Republic). Turonian. FRITSCH & BAYER, 1905.

Pliosauridae ind.:

— Sussex (England). Turonian to Lower Campanian. OWEN, 1851.
— Brabant (Belgium). Santonian to ?Lower Campanian. DOLLO, 1909.
— Scania (Sweden). Campanian. PERSSON, 1959.
— Poland. Santonian. SCHRÖDER, 1885.
— Portugal. Cenomanian. SAUVAGE, 1897.

FAMILIA ELASMOSAURIDAE

Elasmosauridae ind.:

— Sussex (England). Upper Cretaceous. OWEN, 1851.
— Hainaut and Hesbaye (Belgium). Campanian and Maastrichtian. MEYER, 1860; Present paper.
— Netherlands. Maastrichtian. MEYER, 1860; MULDER, 1985 & 1990.
— Scania (Sweden). Campanian to Maastrichtian. PERSSON, 1954 & 1959.
— Poland. Campanian. SCHRÖDER, 1885.

Kent, in the Lower Chalk (Cenomanian) of Cambridgeshire, Kent, Norfolk and Sussex, in the *Plenus* Marls (Cenomanian) of Kent, in the Middle Chalk (Turonian) and in the Upper Chalk (Turonian to Campanian) of Kent and Sussex. *Plesiosaurus constrictus* OWEN, 1850, an elongated cervical vertebra from the Middle Chalk (Turonian: MILNER, 1987) of Sussex (OWEN, 1851, pl. 9, figs.6-7), as well as some elongated and striated teeth from the same area referred to *Plesiosaurus* (OWEN, 1851, pl. 9, figs. 8-10) can be attributed to the Family Elasmosauridae. *Plesiosaurus bernardi* OWEN, 1850, from the Upper Chalk (Turonian to Campanian) of Sussex (OWEN, 1851, pl. 18) is defined on short cervical vertebrae probably belonging to the Family Pliosauridae. The remainder of the material, including *Plesiosaurus smithi* OWEN, 1882 from the Upper Chalk of Kent, can only be referred to as Plesiosauria gen. et sp. indet.

In Belgium, only scant remains have been found in the Upper Cretaceous. DOLLO (1909) mentioned pliosaurid cervical vertebrae from the Glauconie de Lonzée (Santonian to ?Lower Campanian: CHRISTENSEN, 1994). This material (IRSNB 8415) is figured for the first time in the present paper (Plate 1, Figures I-J). *Plesiosaurus houzeaui* DOLLO, 1909, from the Campanian Spiennes Chalk, is described above. A cervical vertebra with a typical dumbbell-shaped articular surface from the Campanian to Maastrichtian Tuffeau de Folx-les-Caves, described by MEYER (1860), is here referred to the Family Elasmosauridae.

In The Netherlands, isolated material has been described only in the Maastrichtian and all can be referred to the Elasmosauridae. They consist of a slender, striated and compressed isolated tooth described as *Goniosaurus binskhorsti* by MEYER, 1860, a morphologically similar tooth from the Laumont horizon of the Nekum Chalk (MULDER, 1990) and cervical vertebrae from the Nekum Chalk (MULDER, 1985).

In Germany, several teeth of the Pliosauridae *Polyptychodon* have been described from the ''Grünsandstein'' (Cenomanian) of Bavaria (MEYER, 1856). *Polyptychodon* teeth are characterized by a circular cross-section and by a crown ornamented by closely and regularly spaced delicate ridges, ending alternatively at the top of the crown or below the apex.

In Sweden, plesiosaurian remains have been described by SCHRÖDER (1885) and PERSSON (1954, 1959, 1962, 1967 & 1990). They probably come from Campanian outcrops. All the material can be referred to both indeterminate Pliosauridae and Elasmosauridae or even to Plesiosauria indet. The first mention of plesiosaurs in Sweden was made by SCHRÖDER (1885, pl. 15, fig. 3) who referred a sacral vertebra to *Plesiosaurus cf. helmerseni*. This vertebra can only be assigned to Plesiosauria indet. The bulk of the material was described by PERSSON in several papers. Elasmosaurid material was described as ''*Elasmosaurus*'' *cf. helmerseni* (PERSSON, 1959, pl. 4), *Scanisaurus cf. nazarowi* (PERSSON, 1959, pls. 6-13), *Elasmosaurus? gigas* (PERSSON, 1959, pl. 5) and Elasmosauridae indet. (PERSSON, 1954; PERSSON, 1959, pl. 14). This material only bears characters allowing its attribution to the Elasmosauridae (for example, the morphology of cervical vertebrae and teeth). The material referred to *Scanisaurus cf. nazarowi* is more complete, including teeth, several vertebrae and limb bones. Nevertheless, these bones do not show any diagnostic characters differentiating this taxon from other Upper Cretaceous Elasmosauridae (see PERSSON, 1967). The pliosaurids were descibed as Polyptychodontidae gen. et sp. indet. (PERSSON, 1959, pl. 3); the characters of the cervical vertebrae and the teeth do not allow a more precise identification. Finally, the material described by PERSSON in 1962 and 1990 can only be referred to the Plesiosauria indet.

From Poland, SCHRÖDER (1885) recognized several taxa. They were found in Turonian to Campanian sandstones. *Plesiosaurus balticus* SCHRÖDER, 1885, from the Santonian (Zone of *Gonioteuthis westphalica*) is based on short posterior cervical and dorsal vertebrae, ribs, a humerus and roughly striated teeth that can be referred to Pliosauridae. *Plesiosaurus helmerseni* KIPRIJANOFF, 1882, from the Campanian, is based on several vertebrae: one of them (SCHRÖDER, 1885, pl. 15, fig. 1) can be referred to the Elasmosauridae because of its elongated centrum bearing a longitudinal crest on its lateral face. The other one (SCHRÖDER, 1885, pl. 15, fig. 2) as well as the Campanian vertebrae attributed to *Plesiosaurus ichthyospondylus* SEELEY, 1869 and *Pliosaurus? gigas* SCHRÖDER, 1885 (SCHRÖDER, 1885, pl.16) can only be referred to Plesiosauria indet.

From the Turonian of Bohemia (Czech Republic), FRITSCH & BAYER (1905, 1906) and BAYER (1916) described fragmentary specimens, including *Polyptychodon* remains. They created specific names for indeterminable plesiosaur fossils (PERSSON, 1963): *Cimoliasaurus lissaensis* FRITSCH, 1905, *Cimoliasaurus teplicensis* FRITSCH, 1905, *Cimoliasaurus vicinus* FRITSCH, 1905, *Hunosaurus fasseli* FRITSCH, 1905 and *Iserosaurus litoralis* FRITSCH, 1905.

Finally, SAUVAGE (1897, p.22, pl.10, fig.1) described a cervical vertebra from the Cenomanian of Alcantara (Portugal) that he referred to *Cimoliasaurus sp.* This cervical vertebra is short (W>H>L) and can be attributed to a pliosaur.

Conclusions

A review of plesiosaur material from the Upper Cretaceous of Europe confirms the presence of two Families: the Elasmosauridae and the Pliosauridae. In Elasmosauridae, the scarcity and non-diagnostical status of the material prevent the identification of either specific or generic taxa. *Polyptychodon* is the only valid genus of Pliosauridae from the Upper Cretaceous of Europe. This genus was defined by OWEN (1841) on teeth from the Cenomanian of England; it is also known in the Cenomanian of Germany (WAGNER, 1853; MEYER, 1856) and in the Turonian of Bohemia (BAYER, 1916) and Texas (WELLES & SLAUGHTER, 1963). The scarcity of the plesiosaur remains from the Upper Cretaceous of Europe

contrasts with the abundance of material discovered in other parts of the world (North and South America, New Zealand), where several taxa are known of Pliosauridae and, especially, Elasmosauridae.

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Caption of the plate

Plesiosaurus houzeaui DOLLO, 1909 (*nomen dubium*), holotype IRSNB R126/1-19, Spiennes Chalk, Upper Campanian, Ciply, Belgium; A-H, vertebrae in anterior (A, C, E, G) and lateral (B, D, F, H) views: A-B, anterior cervical vertebra (IRSNB R126/2), C-D, posterior cervical vertebra (IRSNB R126/3), E-F, pectoral vertebra (IRSNB R126/4), G-H, dorsal vertebra (IRSNB R126/7); K-L, propodials (IRSNB R126/10 and R126/11); M-O, mesopodials (IRSNB R126/15-17); P, fifth metapodial or phalanx (IRSNB R126/18); Q, ilium (IRSNB R126/19).

Pliosauridae indet., IRSNB 8415, Glauconie de Lonzée, Santonian, Lonzée, Belgium; I-J, cervical vertebra in anterior (I) and lateral (J) views. Scales = 5 cm.

Plate 1.