



A belemnite fauna from the Aalenian-Bajocian boundary beds of the Grand Duchy of Luxembourg (NE Paris Basin)

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ABSTRACT - The transition Aalenian-Bajocian boundary marks a crucial point in the diversification of belemnite faunas with the gradual extinction of the Megateuthididae and the rise of a new suborder, the Pachybelemnopseina. During the Early Jurassic, belemnite assemblages had similar composition all across Europe. Noteworthy diversification among Megateuthididae took place during the Late Aalenian. Despite the widespread occurrence of faunas, Aalenian belemnite assemblages are still poorly known in most parts of Europe. Recent collecting undertaken by the Luxembourg Natural History Museum proved that the Upper Aalenian and Lower Bajocian outcrops in southern Luxembourg are exceptionally rich in well-preserved invertebrate faunas, especially belemnites. The Hutberg site near Rumelange yielded a formerly misunderstood form which is described here as *Homaloteuthis murielae* n. sp. The new species had previously been identified as *Homaloteuthis spinata*, a taxon which is redefined here based on a study of original material from the type locality in Germany. The species studied here, e.g. *Eocylindroteuthis corneliaschmittae*, *E. trautscholdi*, *Brevibelus breviformis*, *B. gingensis*, *Homaloteuthis murielae* n. sp., *H. cf. spinata*, *Megateuthis elliptica*, *M. suevica*, *Mesoteuthis cf. benecke*, *Holcobelus blainvillii*, *Hibolites wuerttembergicus*, *Pachybelemnopsis roettingensis*, *P. baculiformis*, come from a well-defined stratigraphic interval (Late Aalenian Murchisonae Zone to Middle Bajocian Humphriesianum Zone). The abundance of Megateuthididae at the Aalenian-Bajocian boundary beds is characteristic of western and central Europe, except the Normandy, whilst the SE European area is characterised by *Pachybelemnopsis*, *Holcobelus*, and *Hibolites* associated with rare *Megateuthis* and *Brevibelus*. To complete the overview, the Luxembourgian belemnites were compared with Aalenian and Bajocian material from nearby Germany and also illustrated. As a result the Luxembourgian assemblages revealed to be more or less comparable to the faunas from SW Germany.

RIASSUNTO - [Una fauna a belemniti al passaggio Aaleniano-Bajociano proveniente dal nord est del Bacino di Parigi (Gran Ducato di Lussemburgo)] - Il limite Aaleniano-Bajociano segna un momento cruciale nella diversificazione delle faune a belemniti nel Giurassico inferiore, in quanto prima le associazioni a belemniti avevano una composizione abbastanza uniforme in tutta l'Europa. Una chiara diversificazione faunistica avvenne nell'Aaleniano superiore. Anche se i ritrovamenti di faune sono frequenti, le associazioni aaleniane a belemniti sono ancora poco conosciute in Europa. Le recenti campagne paleontologiche effettuate dal Museo di Storia Naturale del Lussemburgo hanno evidenziato che gli affioramenti riferibili all'Aaleniano superiore e Bajociano inferiore del Lussemburgo meridionale sono eccezionalmente ricchi di faune di invertebrati particolarmente ben conservate, soprattutto belemniti.

Le belemniti esaminate provengono da un ben definito intervallo stratigrafico, Aaleniano superiore (Zona a Murchisonae) - Bajociano inferiore (Zona a Humphriesianum) e sono state attribuite alle seguenti specie: *Eocylindroteuthis corneliaschmittae*, *E. trautscholdi*, *Brevibelus breviformis*, *B. gingensis*, *Homaloteuthis murielae* n. sp., *H. cf. spinata*, *Megateuthis elliptica*, *M. suevica*, *Mesoteuthis cf. benecke*, *Holcobelus blainvillii*, *Hibolites wuerttembergicus*, *Pachybelemnopsis roettingensis*, *P. baculiformis*.

Le faune analizzate sono state rinvenute in tre sezioni stratigrafiche affioranti nel Lussemburgo meridionale, vicino al confine con la Francia:

1 - "HUTBERG", Rumelange. I sedimenti con belemniti sono riferibili al limite Aaleniano - Bajociano, in particolare dall'Aaleniano superiore (Zona a Murchisonae e Concavum) al Bajociano inferiore (dalla Zona a Discites alla Zona a Propinquans). I rostri sono particolarmente abbondanti nella Zona a Concavum (*Homaloteuthis*, *Brevibelus*, *Holcobelus*), mentre sono meno frequenti nel Bajociano inferiore (*Eocylindroteuthis*, *Brevibelus*).

Da questo affioramento proviene una forma che precedentemente era stata classificata come *Homaloteuthis spinata*, ma che, sulla base di uno studio dettagliato del materiale originale proveniente dalla Germania, è stata qui attribuita ad una specie nuova: *Homaloteuthis murielae*.

2 - "OP DER HEED", Rumelange. I terreni in studio, attribuiti al Bajociano inferiore (Zona a Humphriesianum) e situati 3 km a sud degli affioramenti Aaleniani, sono esposti in un'importante cava, chiamata "Op der Heed" o "Carrière de Rumelange-Ottange". L'abbondante fauna a belemniti consiste soprattutto di *Megateuthis* e *Pachybelemnopsis* con rari *Hibolites*, *Brevibelus* ed *Eocylindroteuthis*.

3 - "GIELE BOTTER", Differdange. Gli strati con belemniti sono riferibili al Bajociano inferiore (Zona Discites - Propinquans). La sequenza essenzialmente corrisponde a quella di Rumelange. Le sequenze marnoso-calcaree del Bajociano inferiore sono facilmente individuabili per due strati a coquina presenti nelle Zone a Laeviuscula e Propinquans. Questi strati contengono una fauna a gasteropodi e bivalvi eccezionalmente ben conservati e rari cefalopodi (*Eocylindroteuthis* e *Brevibelus*).

L'abbondanza di forme appartenenti alla famiglia Megateuthididae al limite Aaleniano-Bajociano è caratteristica dell'Europa centro-occidentale, con l'eccezione della Normandia, mentre nell'Europa sud-orientale sono tipici i generi *Pachybelemnopsis*, *Holcobelus*, *Hibolites* associati a rari esemplari dei generi *Megateuthis* e *Brevibelus*. Per completare lo studio delle faune a belemniti, oltre alle forme provenienti dal Lussemburgo, sono stati esaminati, confrontati e descritti anche esemplari aaleniani e bajociani provenienti da affioramenti della Germania: le associazioni a belemniti del Lussemburgo risultano simili alle faune della Germania sud occidentale.

Le faune a belemniti, provenienti da sedimenti compresi tra la Zona a Murchisonae e la Zona a Humphriesianum, sono particolarmente interessanti per capire lo sviluppo del provincialismo nel Giurassico europeo. Il presente lavoro dimostrerebbe che tali faune nel Lussemburgo e nella Germania sud-occidentale erano identiche. L'Aaleniano superiore è caratterizzato dalla presenza dei generi *Brevibelus*, *Mesoteuthis*, *Holcobelus* e *Homaloteuthis*. Il Bajociano inferiore è invece caratterizzato dalla presenza di *Eocylindroteuthis*, *Brevibelus* e *Megateuthis* (Zona a Discites a Propinquans), associata con i primi elementi tetisiani (*Pachybelemnopsis* e *Hibolites*) arrivati nel Bajociano inferiore (Zona a Humphriesianum). Nell'Europa centro-occidentale la Zona a Humphriesianum segna il passaggio da associazioni dominate da Belemnitina ad associazioni dominate da Pachybelemnopseina.

INTRODUCTION

Belemnites can be considered good biostratigraphic fossils because they are widespread, fast evolving, largely facies independent, simple to identify and abundant.

In the past few years one of the present authors (R.W.) discovered some rare Megateuthididae species from Luxembourg and in some SW German collections so far not described from Luxembourg or from Central Europe at all. The purpose of this paper is to describe these recently collected belemnite assemblages from the Luxembourgian Aalenian-Bajocian transition/boundary beds and to define their exact stratigraphic position. A new species is introduced, and correlations with the coeval German assemblages stored in the Museums of Stuttgart, Tübingen and Berlin, are tentatively drawn. Furthermore, some paleobiogeographic and stratigraphic implications are attempted.

PREVIOUS WORKS

The European Early and Middle Jurassic belemnite faunas, although partly in need of a substantial taxonomic revision, are well known in the Toarcian (Stoyanova-Vergilova, 1977; Doyle, 1990, 1992; Riegraf et al., 1984). The Aalenian-Bajocian faunas have been the object of only sparse systematic and stratigraphic studies related to few outcrops and limited number of specimens collected. Schwegler (1938, 1965, 1971) and Riegraf (1980, 1981) gave an extensive synopsis about Jurassic belemnites in SW Germany and the stratigraphic and geographic distribution of several species belonging to *Megateuthis*, *Mesoteuthis*, *Eocylindroteuthis*, *Homaloteuthis*, *Holcobelus*, *Brevibelus*, *Pachybelemnopsis* and *Hibolites*. Schlegelmilch (1998) mainly compiled information from the previously mentioned authors and refigured some original specimens of Schwegler (1938, 1965, 1971) that previously were only known by highly reduced bad-quality outline drawings. Tripp (1940) represented thin sections of Aalenian and Bajocian belemnites from the Swabian Jurassic. Concerning Northern Germany, the available information is particularly scarce: Althoff (1928) and Waldeck (1975) mentioned *Megateuthis* from the Bajocian of Bielefeld and Lower Saxony. Kumm (1952) reported several belemnite species, among them *Homaloteuthis* and *Megateuthis*, from the Upper Aalenian and Lower Bajocian of Lower Saxony.

Regarding Switzerland and Austria, Buser (1952) and Lieb & Bodmer (1955) quoted *Megateuthis*, *Holcobelus* and *Brevibelus* from the Swiss Jurassic. V. Hochstetter (1897) described Lower Bajocian belemnites from St. Veit near Vienna, including *Brevibelus*, *Megateuthis*, *Pachybelemnopsis* and a new species, *Belemnites eduardi*, included by Stolley (1927) into his new genus *Holcobelus*. In Great Britain already Phillips (1869) represented several specimens of *Megateuthis*, *Holcobelus* and *Pachybelemnopsis*; unfortunately neither recent nor more detailed studies have been accomplished until now. In Belgium, Luxembourg and NE France (Alsace-Lorraine) the first descriptions of Bajocian belemnites go back to Chapuis & Dewalque (1854) who

represented *Megateuthis*. Several specimens, referred nowadays to *Homaloteuthis*, *Brevibelus*, *Megateuthis* and *Pachybelemnopsis*, are reported by Lepsius (1875), Branco (1879), Bleicher (1884), Haug (1886), Van Werveke (1901), Benecke (1901, 1905), Laux (1921-23), Lucius (1945, 1948) and Maubeuge (1955), unfortunately without figures. More recently, Weis (2006) described a *Megateuthis-Pachybelemnopsis* assemblage from the Lower Bajocian, Humphriesianum Zone, of Luxembourg. For NW France, of crucial importance is the belemnite monograph of Eudes-Deslongchamps (1878) about Normandy, where he described *Megateuthis*, *Brevibelus*, and *Pachybelemnopsis* together with several new Upper Aalenian species; unfortunately it has not been revised up to now, although Stolley (1927) created the new genus *Holcobelus* for the latter ones.

Riche (1904), Lissajous (1925) and Roché (1939) recorded *Holcobelus*, *Brevibelus*, *Megateuthis*, and *Pachybelemnopsis* from Central France (Burgundy), and Garnier (1872), Zürcher (1891), Roman & Gennevaux (1912), Gérard (1936), and Riegraf (1980b) *Holcobelus* and *Pachybelemnopsis* from Aalenian/Bajocian boundary of Southern France.

In SE Europe the distribution pattern appears to be somewhat more complete. Stoyanova-Vergilova (1982, 1985, 1990, 1993) gave an extensive overview of Aalenian and Bajocian belemnites in Bulgaria. She quoted and figured several species of *Holcobelus*, *Brevibelus*, *Megateuthis*, *Paramegateuthis*, and *Pachybelemnopsis*. A comparable assemblage with *Megateuthis*, *Brevibelus*, *Holcobelus*, *Pachybelemnopsis* and *Hibolites* is reported by Preda (1975) from the Bajocian of Romania. Such faunas are also reported from Caucasus and Crimea (Krimholz, 1947, 1953). In Southern Italy, Combémoré et al. (1994) reported an isolated belemnite assemblage of Upper Aalenian-Lower Bajocian from Caloveto (Calabria, Italy) with *Holcobelus*, *Pachybelemnopsis*, and

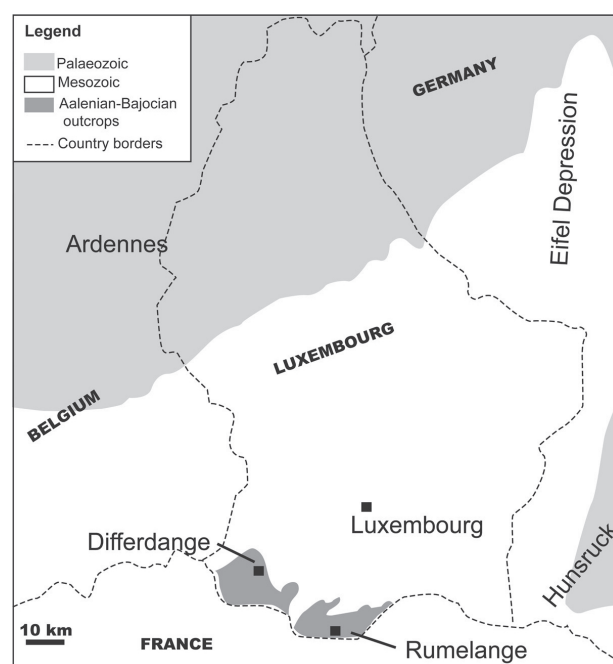


Fig. 1 - Location map of the Aalenian/Bajocian outcrops in Luxembourg.

Megateuthis. Since then, the same site yielded new material that is currently under study by Mariotti et al. (2007).

GEOLOGICAL SETTING

Situated in the north-eastern extension of the Paris Basin, the Grand-Duchy of Luxembourg, despite its very limited geographical area, displays a wide range of geological strata. While the North and East of the country are covered by Palaeozoic and Triassic sediments, the central and southern areas show Jurassic deposits of the Paris Basin margin type, locally known as the Gulf of Luxembourg, characterised by Lower to Middle Jurassic (Hettangian-Bajocian) shallow water (shelf) deposits (Fig. 1). The Jurassic succession has been described in detail by Lucius (1948) and summarised by Bintz et al. (1973). The majority of the Luxembourg Formation names informally introduced by Lucius (1948) and still in use have not yet been revised according international standards and are given here in brackets.

Lower Jurassic

The territory of Luxembourg occupies a marginal position in the Paris Basin: the Early Mesozoic history of the area was mainly influenced by the “Eifel depression”, a N-S striking subsiding zone separating the Ardennes from the Rhenish Massive, through which the northern German sea progressively reached the “Lorraine depression”. On its western border, N-S oriented Triassic shorelines gradually turned into NE-SW directions as the Lower Jurassic sedimentary series advanced across the Ardennes Paleozoic basement. This situation was responsible for the development of some particular facies, like the Luxembourg Formation or “Luxembourg Sandstone” during the Hettangian and Sinemurian, a diachronic formation which consists in a gradual “sanding-up” of the “normal” facies present in the adjacent Lorraine, an alternation of marly and calcareous deposits (Colbach, 2005; Müller & Guérin-Franiatte, 2005). The Luxembourg Sandstone is capped by a hardground, which is followed by the “Marnes et Calcaires de Strassen”, a 6-10 m thick formation of Sinemurian age (Colbach et al., 2003). At the top of the formation, the marly intercalations become dominant over the limestones. A *Promicroceras planicosta* level marks the beginning of a monotonous marly deposit, known as “Marnes pauvres en fossiles”. The formation, 40-60 m thick, is dated as Late Sinemurian and can locally extend into the basal Pliensbachian (Guérin-Franiatte, 2003). In the eastern part of Luxembourg the Upper Sinemurian and basal Pliensbachian are marked by the reappearance of the marly-calcareous alternations, 2-3 m thick (“Calcaire ocreux”), containing rich ammonite faunas of the *Raricostatum* and *Davoei* Zones. The overlying “Couches à *Amaltheus margaritatus*” and “Couches à *Pleuroceras spinatum*”, with a total thickness of 100-120 m, consist of marlstones with fossiliferous calcareous nodules at the top. At the top of the *Spinatum* beds, phosphoritic nodules indicate a regression interval. This characteristic layer, ascribed to the *Tenuicostatum* Zone, is followed by bituminous black shales (“Couches à *Harpoceras falciferum*”) an equivalent of the German

“Posidonienschiefer Formation” and the French “Schistes carton”. They contain a rich cephalopod and vertebrate fauna, with common marine reptiles. The shales reach a thickness of 40-45 m and are ascribed to the *Falciferum* Zone. At their top large calcareous nodules bear *Hildoceras bifrons* (*Bifrons* Zone). A further phosphoritic layer containing numerous ammonite and belemnite fragments, partially redeposited, has been described as “Couches à crassum” (*Crassum* Zone). The lower-energy marly sedimentation takes on again with the Upper Toarcian “Marnes à *Astarte voltzi*”, which continuously change into 20 m of mellow sandstone containing *Grammoceras striatulum* (“Grès supraliasique”, *Thouarsense* Zone). A thin layer with dark marls corresponds to the *Fallaciosum* Zone. It is overlain by the “Couches à *Levesquei* et *Pseudoradosa*” which correspond, in the western part of the Grand Duchy, with the basal beds of the informally named “Minette” Formation, a ferruginous oolite deposit a Late Toarcian to Late Aalenian sequence of up to 12 cycles (with a total thickness of 15-65 m).

Middle Jurassic

The informal “Minette” Formation corresponds to ferruginous oolites, which are widespread in Central and Western Europe, surrounding the small continent masses in the shallow European shelf sea. Stratigraphically the “Minette” Formation ranges from the Upper Toarcian (*Levesquei* Zone) to the Upper Aalenian (*Concavum* Zone). Its outcrop in southern Luxembourg forms a 20-km-wide belt from Pétange to Dudelange (Fig. 1).

The formation is characterised by oolitic ironstones at several horizons of up to 15 detrital coarsening upward cycles, with a total thickness of 15-65 m. The deposit is subdivided into a western part, the Basin of Differdange-Longwy, and an eastern part, the Basin of Esch-Ottange. Important regional and vertical facies variations can be observed: in the lower and western part silicate ores are dominant, while in the upper and eastern parts calcareous goethitic ores are more important. The ironstone facies consists mainly of cross-bedded iron oolites and bioarenitic limestones of a high-energy environment. The intercalated, bioturbated mud- and siltstone facies indicate a lower-energy environment. The alternation of the two facies builds up a sequence of shallowing upward cycles. The “Minette” sediments were deposited in a nearshore shallow marine environment in the subsiding gulf of Luxembourg, surrounded by the lowlands of the Hercynian Rhenish Massive (Siehl & Thein, 1989; Thein, 2005). An important stratigraphic gap tops a part of the Lower Aalenian, which ends with a conglomeratic bed (“Conglomérat de Katzenberg”), which is in turn capped by sandy marls (“Couche rouge marno-sableuse”). These sandy marls yielded a rich and well-preserved ammonite fauna with *Brasilia* and *Ludwigia*, followed by a 0.4 m thick marly bed with *Graphoceras*. The belemnite fauna of these Upper Aalenian marls includes a large number of *Brevibelus*, *Homaloteuthis*, and *Holcobelus*, while the lower part of the “Minette” Formation is characterised by an assemblage of *Brevibelus*, *Mesoteuthis*, *Acrocoelites*, and *Hastites* (Weis, 1999).

The “Minette” Formation is overlain by marls (“Marnes micacées”, “Couches à *Sonninia*”) dated as basal Bajocian,

followed by biotrital, ferruginous limestones ("Calcaire de Haut-Pont"). The youngest Bajocian sediments, outcropping on the French-Luxembourgian boundary area consists of biotrital limestones, containing coral reef bioherms ("Marnes et calcaires d'Audun-le-Tiche"). They contain a rich invertebrate fauna and have yielded an important belemnite assemblage with *Megateuthis* and *Pachybelemnopsis* (Weis, 2006).

The Middle Jurassic sequence is chiefly exposed around Rumelange and Differdange, from where the studied rostra were collected.

THE SECTIONS

In the southern part of Luxembourg, close to the French border, the outcropping ferruginous strata, ranging from the Upper Toarcian to the Upper Aalenian, have been exploited in numerous extensive opencast pits. Though abandoned since the early 70's of the 20th century, these sites do still permit excellent geological studies. During the last years, investigations under the coordination of the Luxembourg Natural History Museum enabled collecting an important number of invertebrate fossils. Amongst the collected fossils, belemnites represent a prominent part, being mostly well preserved.

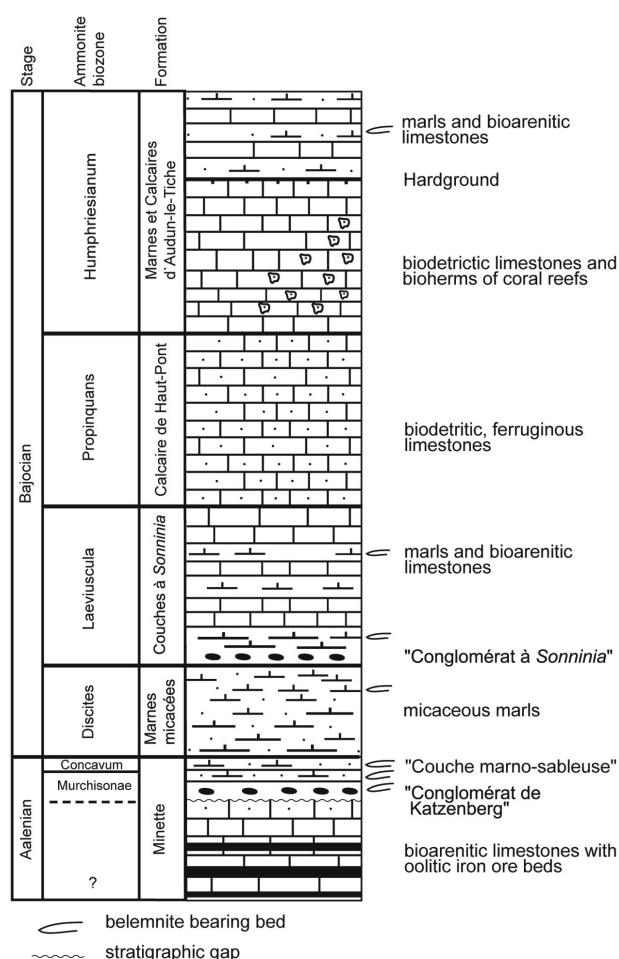


Fig. 2 - Schematic section of the Middle Jurassic sequence at Hutberg, Rumelange (Luxembourg).

"HUTBERG", Rumelange (Aalenian-Bajocian boundary): the exposed sequence (Fig. 2) covers the ferruginous Upper Aalenian (Murchisonae and Concavum Zone) and the Lower Bajocian (Discites to Propinquans Zone). Belemnites are particularly frequent in the Concavum Zone (*Homaloteuthis*, *Brevibelus*, *Holcobelus*), while they occur only sparsely in the Lower Bajocian (*Eocylindroteuthis*, *Brevibelus*).

The stratigraphy of the site is described in detail by Guérin-Franiatte & Weis (in press) (Fig. 3).

"OP DER HEED", Rumelange (Lower Bajocian, Humphriesianum Zone): situated 3 km south of the Aalenian outcrops, the Humphriesianum Zone (Fig. 2) is exposed in an important quarry, called "Op der Heed" or "Carrière de Rumelange-Ottange" (Fig. 4). The abundant belemnite fauna consists mainly of *Megateuthis* and *Pachybelemnopsis* with rare *Hibolites*, *Brevibelus*, and *Eocylindroteuthis* (Weis, 2006).

An overview of the paleoenvironment and the fauna is described in Fayard et al. (2005).

"GIELE BOTTER", Differdange (Lower Bajocian): the exposed sequence (Fig. 5) essentially corresponds to that of Rumelange. The belemnite-bearing Concavum Zone, however, is not accessible in this area. The Lower Bajocian marly and calcareous sequences are easily traceable, with two prominent coquina beds in the Laeviuscula and the Propinquans Zones. These coquina beds are yielding an exceptionally well-preserved gastropod and bivalve-fauna, with sparse cephalopods

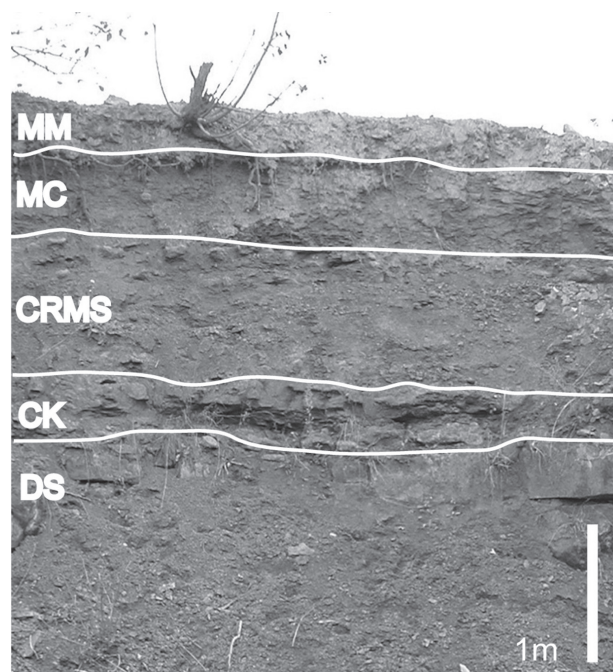


Fig. 3 - The Upper Aalenian outcrop at Hutberg, Rumelange (Luxembourg) with the undated "Dachsandstein" (DS), the "Conglomérat de Katzenberg" (CK, Murchisonae Zone), the "Couche rouge marno-sableuse" with ammonite-bearing nodules (CRMS, Murchisonae Zone), the belemnite-bearing sandy marls of the Concavum Zone (MC) and the basal Bajocian "Marnes micacées" (MM).

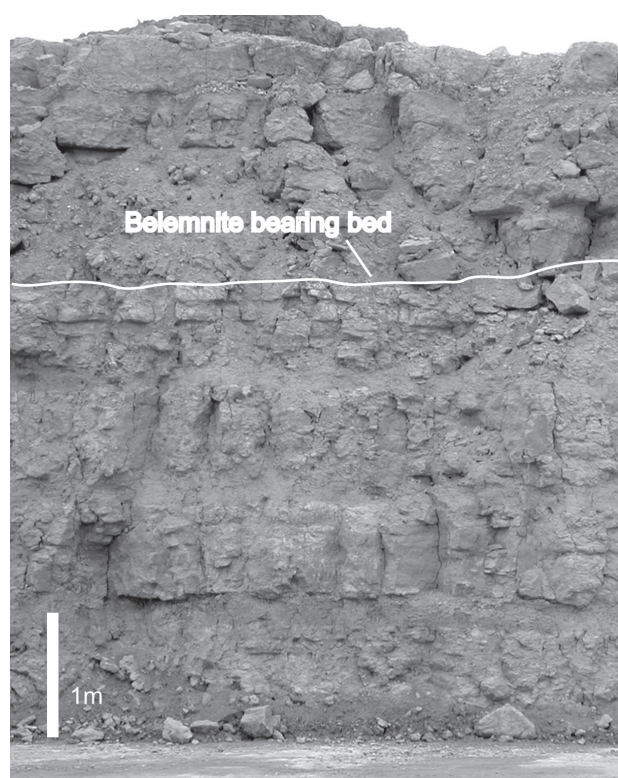


Fig. 4 - The “Marnes d’Audun-le-Tiche” (Bajocian, Humphriesianum Zone), at the quarry “Op der Heed” near Rumelange. The indicated bed yields several rostra of *Megateuthis* and *Pachybelemnopsis*.

(e.g. *Eocylindroteuthis* and *Brevibelus*). Lithostratigraphic details are found in Köwius (1977).

MATERIAL AND METHODS

About 300 belemnites collected from strata of the Upper Aalenian to Lower Bajocian from Luxembourg, Eastern France and Southwest Germany have been examined. The described rostra are stored in the following collections:

IMGT: Institut und Museum für Geowissenschaften, Tübingen.

MAN: Muséum Aquarium de Nancy.

MB: Museum für Naturkunde, Humboldt-Universität Berlin.

MnhnL: Musée national d’histoire naturelle, Luxembourg (including specimens of collection Dr. Wolfgang Riegraf with their original catalogue number).

SMNS: Staatliches Museum für Naturkunde, Stuttgart.

NG: Collection Nico Gross, Bous/Luxembourg, Research associate of the Luxembourg Natural History Museum.

ES: Collection Eugène Soirfeck, Nilvange/France, Research associate of the Luxembourg Natural History Museum.

The terminology used herein is adopted from Riegraf et al. (1998). Individual descriptions also include size

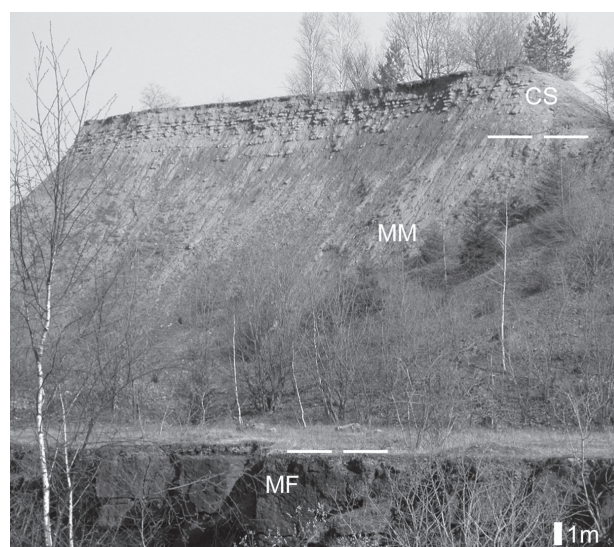


Fig. 5 - The Early Bajocian section with the belemnite-bearing limestones of the Laeviuscula Zone (Couches à *Sonninia*) near Differdange (Luxembourg). MF = “Minette” Formation; MM = “Marnes micacées”; CS = “Couches à *Sonninia*”.

measurements in cases of complete or almost complete rostra. All measurements are given in millimetres. Dimensional adjectives are used as in Doyle & Kelly (1988); the terms small, medium and large, related to the length of the rostrum (L), are respectively referred to $L < 80$ mm, L between 80 and 110 mm and $L > 110$ mm.

Abbreviations follow Combémoré & Mariotti (1986): R = total preserved length; RS = total length of the rostrum solidum (from the protoconch to the apex); Hi = maximum height at the position of the protoconch (or the anterior fracture); Li = maximum breadth at the position of the protoconch (or the anterior fracture); Hm = maximum height of the rostrum; Lm = maximum breadth of the rostrum; lc = compression index. This represents the ratio of height to breadth at given points along the longitudinal axis of the rostrum.

All the rostra are well preserved with the phragmocone observable in most specimens.

SYSTEMATICS

The classification adopted here is based on Riegraf (1995) and Riegraf et al. (1998).

Order BELEMNITIDA MacGillivray, 1840
Suborder BELEMNITINA MacGillivray, 1840
Family CYLINDROTEUTHIDIDAE Stolley, 1919

Genus *Eocylindroteuthis* Riegraf, 1980

Diagnosis - Medium-large sized robust Cylindroteuthidae. Outline and profile conical to cylindriconeal. Rostrum laterally compressed. Intermediate ventral depression or groove. Apical region elongated, slightly to strongly compressed, lacking grooves.

Type species - Belemnites trautscholdi Oppel, 1862.

Eocylindroteuthis corneliaschmittae Riegraf, 1980
(Pl. 1, figs. 1-3; Pl. 2, figs. 1-2; Pl.3, fig.1; Figs. 6d, g)

- v* 1980 *Eocylindroteuthis corneliaschmittae* RIEGRAF, p. 159, text-fig.143-145.
1995 *Eocylindroteuthis corneliaschmittae* RIEGRAF, p. 72.
1997 *Eocylindroteuthis trautscholdi* (Oppel) - COMBÉMOREL, p. 164, Pl. 27 fig. 21.
v. 1998 *Eocylindroteuthis corneliaschmittae* Riegraf - SCHLEGELMILCH, p. 78, Pl. 15 figs. 4-5.
v. 2005 *Eocylindroteuthis corneliaschmittae* Riegraf - WEIS & GROSS, p. 69, text-fig. A6.
v. 2006 *Eocylindroteuthis corneliaschmittae* Riegraf - WEIS, p. 159, fig. 11.

Material - Two specimens from the Lower Bajocian of St. Aignon and Champigneulle NE France (MAN DOG186-86, DOG76-190), one specimen from the Propinquans Zone of Differdange/Luxembourg (MnhnL BU146), five specimens from the Laeviuscula Zone of Differdange/Luxembourg (MnhnL ZS416, ZS451, ZS535, ZS536, RB121), three specimens from the Discites Zone of Ringsheim/SW-Germany (MnhnL DOT176, former Riegraf collection WR 2655, 2656, 2657), one specimen from the Lower Bajocian of Schlatt bei Hechingen/SW Germany (IGMT 1532/127), one specimen from the Discites Zone of the Plettenberg hill near Balingen/SW Germany (IGMT 1532/124), two specimens from the Laeviuscula Zone of the Plettenberg hill near Balingen/SW Germany (IGMT 1532/125-126), one specimen from the Lower Bajocian of Rumelange/Luxembourg (MnhnL BU114), seven specimens of *E. cf. corneliaschmittae* from the Concavum Zone of Rumelange/Luxembourg (MnhnL HU280, HU351a, 370, 372, 374, 375), two specimens from the Laeviuscula Zone of Ringsheim/SW Germany (SMNS 66255/1-2), one specimen from the Laeviuscula Zone of Eichberg, Wutach/SW-Germany (SMNS 66254).

Diagnosis - Large, cylindriconeal *Eocylindroteuthis*. Outline symmetrical and cylindriconeal or slightly cylindrical. Profile asymmetrical, otherwise similar to the outline. Transverse sections compressed elliptical with a ventral flattening. Apex acute. Intermediate ventral depression. No apical grooves.

Description - Large, slender to robust rostra that are commonly cylindriconeal, although some individuals can be more cylindrical (Pl.1, fig.2). The outline is symmetrical

and cylindriconeal to cylindrical. The profile is generally similar to the outline although being asymmetrical. The transverse sections are compressed elliptical with a flattened venter, due to the ventral depression. The ventral depression reaches neither the apex nor the alveolar region and is generally better developed in younger individuals than in adults, which frequently show only a slight ventral flattening. The elongated apical region shows an asymmetric profile and is generally strongly compressed. The apex shows no grooves, fine striae on the tip indicate a weakly developed epirostrum, apparent in longitudinal sections (Pl. 2, figs. 1c, 2). The apical line is diffuse as in *Megateuthis* and *Mesoteuthis* indicating an epirostral tendency already in juveniles. The phragmocone penetrates one third to one quarter of the rostrum.

Dimensions

N°	R	RS	H	Li	lci	Hm	Lm	lcm
MnhnL BU146	90	61	15.2	12.9	1.18	-	-	-
MnhnL ZS451	175	-	-	-	1.89	1.69	1.18	-

Ontogeny - Juveniles are strongly cylindriconeal and show a well-developed ventral depression (Fig. 6d). Very young rostra (<2 cm length) show additionally two dorsolateral depressions, which are lost during the subsequent stages. The sub-adult stage (Pl. 1, fig. 2; Pl. 2, fig. 1) is generally slender, the ventral depression fades and can disappear in some individuals, being replaced by a barely perceptible ventral flattening. At this stage, the species develops a short epirostrum and grows considerably in thickness, which leads to more robust forms (Pl. 1, fig. 1; Fig. 6g).

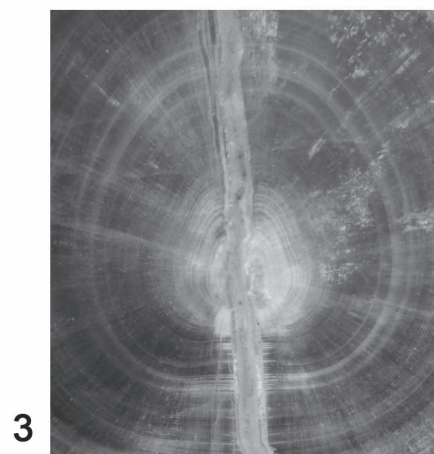
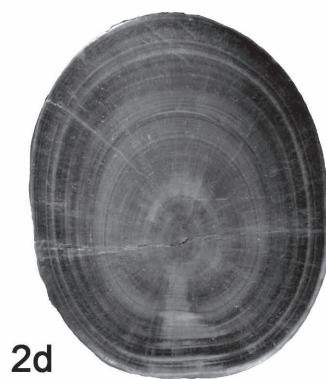
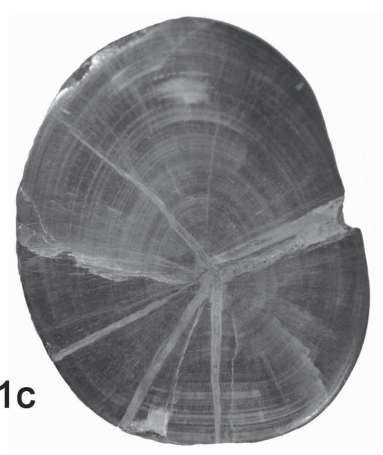
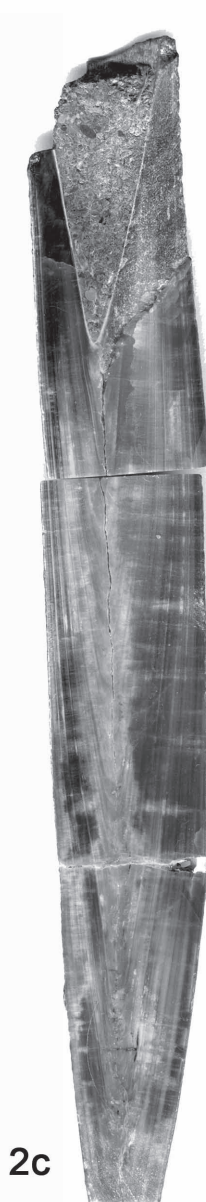
Remarks - *E. corneliaschmittae* may be confused with *E. trautscholdi* (Oppel), which differs by its conical shape, a symmetric, elongated apical region, a lesser compressed transverse section and a more marked intermediate ventral groove, present at all growth stages. If the intermediate ventral depression is not apparent due to poor conservation, the slender specimens can be confused with *Megateuthis elliptica* (Miller), which is similar in shape but distinguished by its well-developed dorsolateral grooves. *Homaloteuthis murielae* n. sp. distinguishes by its slender very elongated apical region and the absence of a ventral depression.

Stratigraphic range and geographical distribution - ?Upper Aalenian (Concavum Zone) and Lower Bajocian (Discites-Humphriesianum Zones) of SW Germany, NE France (Lorraine), Luxembourg, Belgium, possibly NW Germany (Bielefeld area).

EXPLANATION OF PLATE 1

figs. 1-3 - *Eocylindroteuthis corneliaschmittae* Riegraf, 1980.

- 1 - Adult specimen, Bajocian, Laeviuscula Zone, Differdange/Luxembourg, MnhnL ZS535. Lateral (1a) and ventral (1b) views, x 1; transverse section (1c), x 2.
- 2 - Sub-adult specimen, Bajocian Laeviuscula Zone, Differdange (Luxembourg), MnhnL ZS536. Lateral (2a) and ventral (2b) views, x 1; longitudinal section (2c), x1; transverse section (2d), x 2.5.
- 3 - Detail of the transverse section of the specimen MnhnL RB121, also figured on Pl. 2, figs.1a-d (x 4.5).



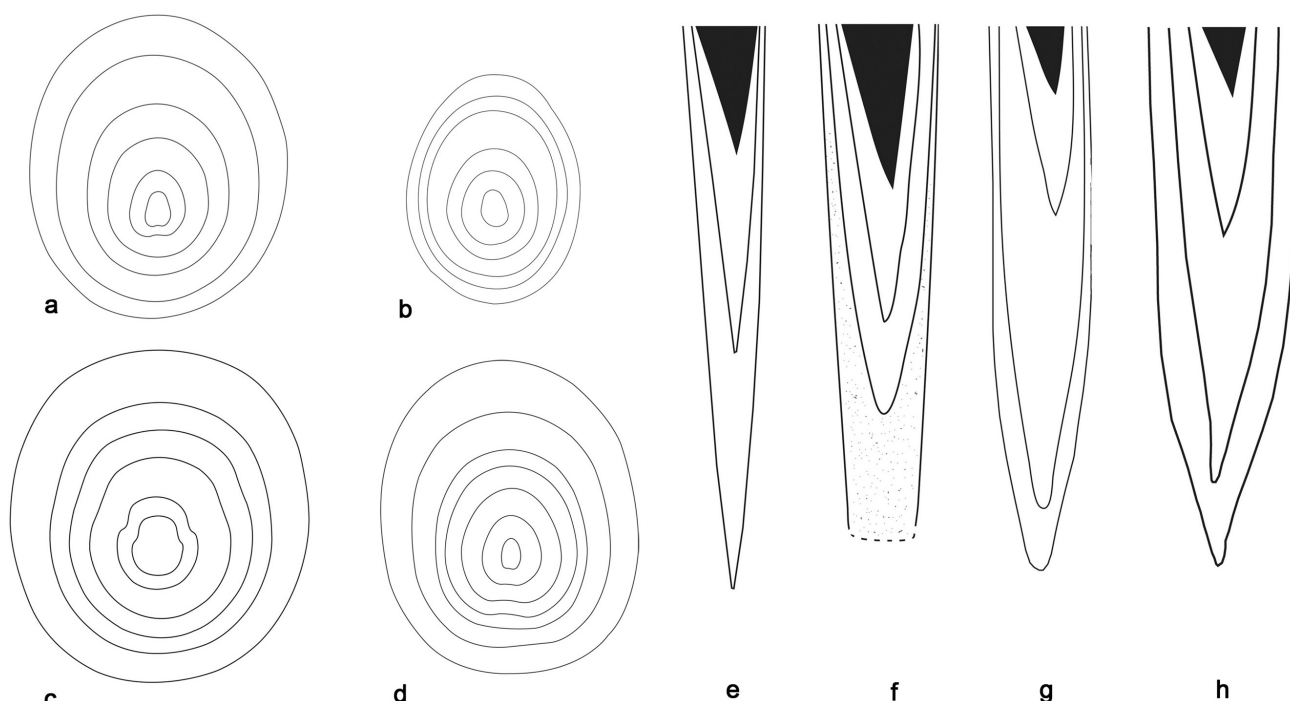


Fig. 6 - Schematic ontogeny of Aalenian and Bajocian belemnite species. a) *Homaloteuthis spinata* (Quenstedt, 1848), transverse section of the rostrum solidum just behind the protoconch. b) *Homaloteuthis murielae* n. sp., transverse section of the rostrum solidum just behind the protoconch. c) *Megateuthis suevica* (Klein, 1773), transverse section of the rostrum solidum just behind the protoconch. d) *Eocylindroteuthis corneliaschmittae* Riegraf, 1980, transverse section of the rostrum solidum just behind the protoconch. e) *Homaloteuthis murielae* n. sp., longitudinal section. f) *Megateuthis suevica* (Klein, 1773), longitudinal section, the spotted area represents the epirostrum. g) *Eocylindroteuthis corneliaschmittae* Riegraf, 1980, longitudinal section. h) *Homaloteuthis spinata* (Quenstedt, 1848), longitudinal section.

Eocylindroteuthis trautscholdi (Oppel, 1862)
(Pl. 3, fig. 2)

- * 1862 *Belemnites trautscholdi* OPPEL, p. 127.
- v. 1980 *Eocylindroteuthis trautscholdi* (Oppel) - RIEGRAF, p. 155, text-fig. 139-141 (*cum syn.*).
- 1995 *Belemnites trautscholdi* Oppel - RIEGRAF, p. 72.
- non 1997 *Eocylindroteuthis trautscholdi* (Oppel) - COMBÉMOREL, p. 164, Pl. 27, fig. 21 (= *Eocylindroteuthis corneliaschmittae* ?).
- v. 1998 *Eocylindroteuthis trautscholdi* (Oppel) - SCHLEGELMILCH, p. 77, Pl. 15, figs. 1-2.

Material - Two specimens from the Lower Bajocian of Piedmont/NE France (MnhnL BU208), one specimen from the Laeviuscula Zone of Differdange/Luxembourg (MnhnL ZS533), one specimen from the Laeviuscula Zone of Weilen-Deilingen/SW Germany (IMGT coll. Wiedmann), one specimen from the Discites Zone of the Plettenberg near Balingen/SW Germany (IMGT 1532/121), three specimens from the Laeviuscula Zone of the Eichberg-Wutach River/SW Germany (SMNS 66253; 66256; 66259).

Diagnosis - Medium sized, robust conical *Eocylindroteuthis*. Outline symmetrical, conical. Profile symmetrical to slightly asymmetrical, conical. Apex acute, no apical grooves. Transverse section compressed, slightly triangular to elliptical. Intermediate ventral groove.

Description - Medium sized, robust conical rostrum. The outline is symmetrical and strongly conical. The profile is symmetrical although a slightly inflated dorsum may produce a slightly asymmetrical profile, as seen in the holotype. The rostrum is tapering regularly, so that the apical region extends in a remarkably symmetric way. This feature is already observed in juveniles. The apex is acute and lacks grooves. If preserved, the tip of the apex is compressed. The apex bears no grooves; the tip of the apex presents fine striae, when the preservation is favourable, indicating a tendency to develop an epirostrum. The venter shows an intermediate narrow depression, which may be more incised and forms an intermediate groove. This depression or groove reaches

EXPLANATION OF PLATE 2

figs. 1-2 - *Eocylindroteuthis corneliaschmittae* Riegraf, 1980.

- 1 - Sub-adult specimen, Bajocian, Laeviuscula Zone, Differdange/Luxembourg, MnhnL RB121. Lateral (1a) and ventral (1b) views, x 1; longitudinal section (1c), x 1.3; transverse section (1d), x 2.
- 2 - Longitudinal section of the specimen MnhnL ZS535, also figured on Pl. 1, figs. 1a-c (x 1.5).



neither the apex nor the alveolar region. The transverse section is moderately compressed. Due to the flattened venter in the stem region it is slightly pentagonal to triangular becoming more elliptical in the apical and alveolar region.

Ontogeny - Juveniles are slender and conical and already similar to adults.

Remarks - *E. trautscholdi* may be confused with *E. corneliaschmittae* Riegraf, which is distinguished by its cylindric shape, the more compressed and elliptical transverse section, the less elongated apical region with a slightly inflated venter and a less apparent intermediate ventral depression. Juveniles of *Megateuthis elliptica* (Miller) are similar in shape but lack the intermediate ventral groove and show already slightly developed dorsolateral grooves.

Stratigraphic range and geographical distribution - Lower Bajocian (Discites to Humphriesianum Zones) of SW Germany, NE France (Lorraine), Luxembourg, Belgium, Switzerland (Ct. Aargau).

Family MEGATEUTHIDIDAE Sachs & Naljaeva, 1967

Genus *Brevibelus* Doyle, 1992

Diagnosis - Small, short and robust, cylindric to conical Megateuthididae. Outline symmetrical and conical to cylindric, profile symmetrical to slightly asymmetrical, otherwise similar to the outline. Apex obtuse to moderately acute, often mucronate. Transverse sections subquadrate, compressed in some species, depressed in others. No apical grooves or striae. Lateral lines usually well developed. The phragmocone is ventrally displaced, penetrating one half to one third of the rostrum.

Type species - *Belemnites breviformis* Voltz, 1830.

Brevibelus breviformis (Voltz, 1830)
(Pl. 3, figs. 3-4, 7)

* 1830 *Belemnites breviformis* VOLTZ, p. 42, Pl. II, figs. 2-4.

1992 *Brevibelus breviformis* (Voltz) - DOYLE, p. 62, Pl. 23, figs. 6, 10-11; Pl. 24, figs. 1-2 (*cum syn.*).

1995 *Brevibelus breviformis* var. A-C Voltz - RIEGRAF, p. 49.

1996 *Brevibelus breviformis* (Voltz) - RIEGRAF, p. 27, text-fig. 24a.

1997 *Brevibelus breviformis* (Voltz) - COMBÉMOREL, p. 159, Pl. 27, fig. 15.

1998 *Brevibelus breviformis* (Voltz) - SCHLEGELMILCH, p. 68, Pl. 13, figs. 5-6.

v. 1999 *Brevibelus breviformis* (Voltz) - WEIS, p. 222, figs. 4-5, 27-29.

v. 1999 *Brevibelus subbreviformis* (Lissajous) - WEIS, p. 225, fig. 32 (compressed variant).

Material - Seventy-one specimens from the Upper Aalenian to Lower Bajocian (Murchisonae to Discites Zones) from Rumelange/Luxembourg (MnhnL HU212-213, HU222-223, HU226, HU228, HU281-284, HU327, HU353).

Diagnosis - Small, conical to cylindric *Brevibelus*. Outline symmetrical, conical. Profile nearly symmetrical, cylindric. Venter slightly flattened. Apex rounded to acute, without grooves. Transverse section slightly depressed, subquadrate or elliptical.

Description - Small and robust, cylindric to conical rostra. The outline is symmetrical and conical, the profile is less symmetrical and generally more cylindric than the outline, with a slightly flattened venter. The apex is generally rounded and blunt, becoming more acute and mucronate in some cases. There are no grooves. The transverse section is generally depressed and subquadrate in the alveolar region, but becomes more rounded and elliptical in the stem region. Individuals from the Concavum Zone showing a compressed transverse section have been described as *Brevibelus subbreviformis* (Lissajous, 1927) but are included here into the range of variability of the species. Lateral lines are weakly developed. The phragmocone penetrates approximately one half of the rostrum (Pl. 3, fig. 4).

Ontogeny - The slender juvenile rostra grew considerably in thickness during adult stage. The final growth stage is characterised by an elongated, cylindric rostrum with a mucronate apex (Pl. 3, fig. 7).

EXPLANATION OF PLATE 3

fig. 1 - *Eocylindroteuthis corneliaschmittae* Riegraf, 1980. Holotype, adult specimen, Bajocian, Humphriesianum Zone, Schlatt near Hechingen/SW Germany, IMGT 1532/127. Lateral (1a) and ventral (1b) views, x 1.

fig. 2 - *Eocylindroteuthis trautscholdi* Oppel, 1862. Sub-adult specimen, original of Riegraf 1980, text-fig. 140, Bajocian, Discites Zone, Plettenberg near Balingen/SW Germany, IMGT 1532/121. Lateral (2a) and ventral (2b) views, x 1.

figs. 3-4, 7 - *Brevibelus breviformis* (Voltz, 1830).

3 - Juvenile specimen, Aalenian, Concavum Zone, Rumelange/Luxembourg, MnhnL HU281. Lateral (3a) and ventral (3b) views, x 1;

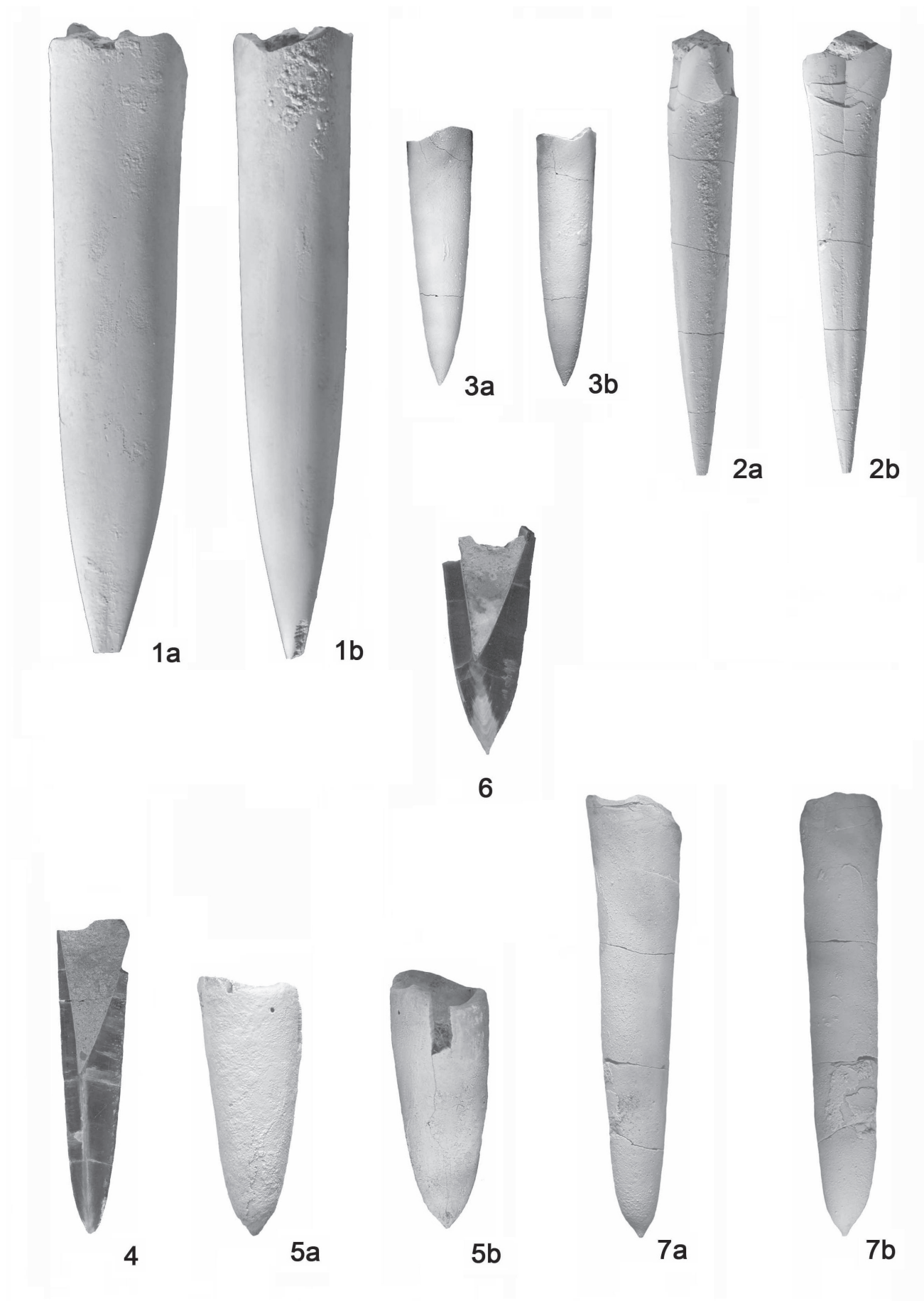
4 - Longitudinal section, Aalenian, Concavum Zone, Rumelange/Luxembourg, MnhnL HU353 (x 1).

7 - Adult specimen, Aalenian, Concavum Zone, Rumelange/Luxembourg, MnhnL HU213. Lateral (7a) and ventral (7b) views, x 1.

figs. 5-6 - *Brevibelus gingensis* (Oppel, 1856).

5 - Adult specimen, Bajocian, Discites Zone, Rumelange/Luxembourg, MnhnL BU212. Lateral (5a) and ventral (5b) views, x 1.

6 - Longitudinal section, Lower Bajocian, Grand-Duchy of Luxembourg, MnhnL BU227 (x 1).



Remarks - *B. breviformis* can be easily distinguished from *B. gingensis*, which is more robust and conical. Juveniles of *Homaloteuthis* may approach *B. breviformis* in shape but are distinguished by a more elongated, conical, acute apex and a compressed transverse section.

Stratigraphic range and geographical distribution - Upper Toarcian (Dispansum Zone) to Lower Bajocian (Humphriesianum Zone) of Europe, Russia and Canada.

Brevibelus gingensis (Oppel, 1857)
(Pl. 3, figs. 5-6)

- * 1857 *Belemnites gingensis* OPPEL, p. 362.
- ? 1992 *Brevibelus* cf. *gingensis* (Oppel) - DOYLE, p. 63, Pl. 24, fig. 6 (*cum syn.*).
- 1995 *Brevibelus gingensis* (Oppel) - RIEGRAF, p. 49.
- 1998 *Brevibelus gingensis* (Oppel) - SCHLEGELMILCH, p. 69, Pl. 13, figs. 7-8.
- v. 2006 *Brevibelus gingensis* (Oppel) - WEIS, p. 157, fig. 11.

Material - Two specimens from the Discites Zone from Rumelange/Luxembourg (MnhnL HU328, BU212), one specimen from the Lower Bajocian of Luxembourg (MnhnL BU227).

Diagnosis - Small, conical *Brevibelus*. Outline and profile symmetrical and conical. Venter flattened. Apex acute, mucronate and devoid of grooves. Transverse sections subquadrate, moderately compressed.

Description - Small, robust and conical rostra. The outline is symmetrical and conical to cylindriconeal. The profile is similar to the outline. The venter is flattened. The apex bears no grooves and is mucronate in adults. Transverse sections are subquadrate and moderately compressed. The phragmocone penetrates approximately one half of the rostrum.

Remarks - *B. gingensis* differs from *B. breviformis* which is more cylindriconeal and less robust.

Stratigraphic range and geographical distribution - Upper Aalenian (Murchisonae Zone) to Lower Bajocian

(Humphriesianum Zone) of Southern Germany, Luxembourg, Belgium, Eastern France, and England.

Genus *Homaloteuthis* Stolley, 1919

Diagnosis - Large or medium-sized, cylindriconeal Megateuthididae. Outline symmetrical and conical, profile asymmetrical and cylindriconeal. Apex acute and devoid of grooves. Transverse sections elliptical and compressed. Phragmocone ventrally displaced.

Type species - *Belemnites spinatus* Quenstedt, 1848.

Homaloteuthis murielae n. sp.
(Pl. 4, figs. 1-8; Figs. 6b, e)

- 1879 *Belemnites spinatus* Quenstedt. - BRANCO, p. 103 (pars).
- 1919 *Belemnites (pseudospinatus)* KLÜPFEL, p. 290.
- 1921 *Belemnites spinatus* Quenstedt. - LAUX, p. 9.
- v. 1945 *Belemnites spinatus* Quenstedt. - LUCIUS, p. 100 (pars).

Derivatio nominis - Dedicated to our friend Muriel Moritz, Luxembourg.

Holotype - Specimen MnhnL n° HU363 (Pl. 4, fig. 1).

Paratypes - Twelve specimens (MnhnL HU364-369, HU376-380, HU351) (Pl. 4, figs. 2-8).

Additional material - One specimen from the Upper Aalenian of Differdange/Luxembourg (MnhnL DOT143), two specimens from the Upper Aalenian, Concavum Zone of Bouxières-aux-Dames, Lorraine/France (MAN DOG78-230; DOG76-220), one specimen from the Lower Bajocian, Discites Zone from Ringsheim/SW Germany (MnhnL DOT177, former Riegraf collection WR 2654).

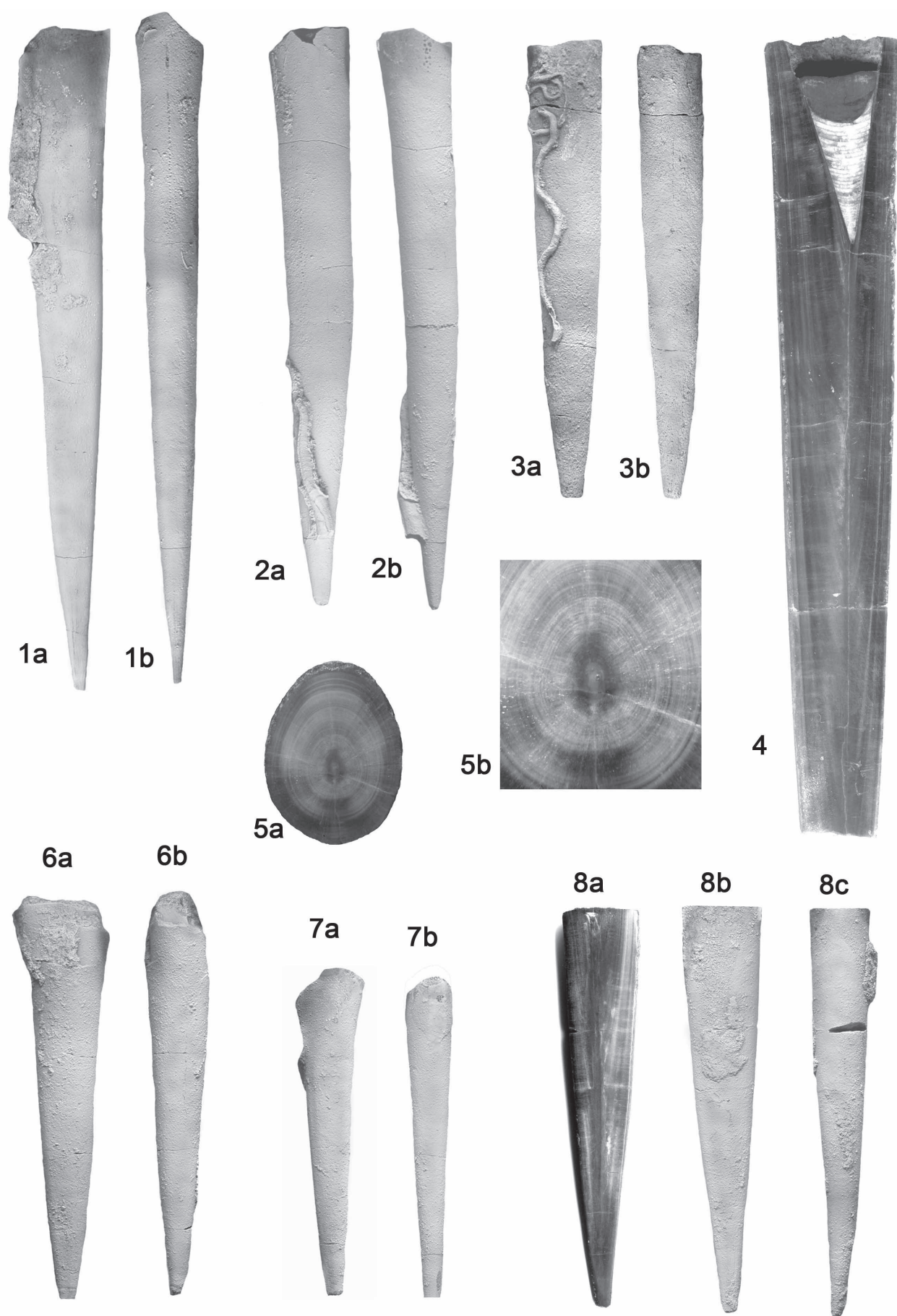
Locus typicus - "Hutberg", abandoned open-cast pit near Rumelange, Luxembourg.

Stratum typicum - "Couche rouge marnosableuse", Concavum Zone, Upper Aalenian.

EXPLANATION OF PLATE 4

figs. 1-7 - *Homaloteuthis murielae* n. sp.

- 1 - Holotype, adult specimen, Aalenian, Concavum Zone, Rumelange/Hutberg, MnhnL HU363. Lateral (1a) and ventral (1b) views, x 1.
- 2 - Adult specimen, paratype, Aalenian, Concavum Zone, Rumelange/Hutberg, MnhnL HU378. Lateral (2a) and ventral (2b) views, x 1.
- 3 - Sub-adult specimen, paratype, Aalenian, Concavum Zone, Rumelange/Hutberg, MnhnL HU367. Lateral (3a) and ventral (3b) views, x 1.
- 4 - Longitudinal section, paratype, Aalenian, Concavum Zone, Rumelange/Hutberg, MnhnL HU369 (x 1.5).
- 5 - Paratype, Aalenian, Concavum Zone, Rumelange/Hutberg, MnhnL HU368. Transverse section (5a), x 2.6; detail of fig. 5a (5b), x 5.5.
- 6 - Juvenile specimen, paratype, Aalenian, Concavum Zone, Rumelange/Hutberg, MnhnL HU365. Lateral (6a) and ventral (6b) views, x 1.
- 7 - Juvenile specimen, paratype, Aalenian, Concavum Zone, Rumelange/Hutberg, MnhnL HU380. Lateral (7a) and ventral (7b) views, x 1.
- 8 - Apical fragment of an adult specimen, paratype, Aalenian, Concavum Zone, Rumelange/Hutberg, MnhnL HU366. Longitudinal section (8a), lateral (8b) and ventral (8c) views, x 1.



Diagnosis - Medium-sized, cylindriconeal *Homaloteuthis*. Outline cylindriconeal, symmetrical, profile cylindriconeal to conical, slightly asymmetrical, venter moderately inflated. Apex acute and striated, but devoid of grooves. Transverse sections compressed elliptical.

Description - Medium sized, gracile and slender rostrum. The outline is cylindriconeal and symmetrical, conical in juveniles. The profile is cylindriconeal, although some individuals may be more conical, and slightly asymmetrical due to a moderately inflated venter. The apex is acute to very acute. Characteristic is the elongated apical region. Well-preserved specimens show striae on the apex, indicating the presence of a short epistrostrum, which is confined to a few millimetres and only present in adults. Transverse sections of the rostrum are highly compressed and elliptical. There are neither apical nor alveolar grooves. Lateral lines have not been distinguished in the type material. The phragmocone is weakly displaced ventrally and penetrates approximately one fifth of the rostrum. The apical line is diffuse in the apical region (Pl. 4, fig. 8a), indicating the epistrostral tendency.

Dimensions

N°	R	Rs	Hi	Li	Ici	Hm	Lm	Icm
HU367	83	66	12.2	10.3	1.18	12.6	10.5	1.20
HU376	105	78	12.4	9.7	1.28	13.1	10.6	1.2

Ontogeny - The primordial rostrum appears as a perfect cone, developing a regular ontogeny (in contrast to *H. spinata*), growing chiefly in length but only weakly in width (Fig. 6e): the juveniles are slender, cylindriconeal forms with an elliptical, compressed transverse section. At a very early stage they show weak hints of dorsolateral depressions, indicating a possible phylogenetic relationship with *Megateuthis*, but no ventral depression (Fig. 6b) as seen in the earliest stage of *H. spinata*. The adult form is characterised by a pronounced length growth, developing a very short epistrostrum, which is confined to the striated extremity of the apex.

Remarks - Within *Homaloteuthis*, *H. murielae* differs from *H. spinata* in that the latter species possesses a robust conical shape, a short asymmetric apical region, a more inflated venter, a mucronate apex in adults, a less regular ontogeny, stronger compression of the transverse

section and a notably deeper penetrating alveolus. *H. murielae* approaches slender specimens of *Eocylindroteuthis corneliaschmittae*, which is characterised by an intermediate ventral depression, a shorter apical region, an inflated venter and a diffuse apical line, with a more pronounced tendency to develop an epistrostrum. Juveniles of *Eocylindroteuthis corneliaschmittae* are more conical with an asymmetrical profile. Juveniles of *Eocylindroteuthis trautscholdi* differ only by the presence of the intermediate ventral furrow.

H. murielae, common in the Upper Aalenian of Luxembourg, has already been reported by various authors working in the area (see list of synonyms), and was identified as *H. spinata*. Only Klüpfel (1918, p. 290) was the only one who took notice of that species, and quoted it as "*Belemnites (pseudospinatus)*" from the "Bradfordense Sandmergel" (Murchisonae Zone) and the "Glimmermergel mit Ammonites discites" (Discites Zone) from Northern Lorraine, which is most likely synonymous with *H. murielae* n. sp.

Stratigraphic range and geographical distribution - Upper Aalenian (Concavum Zone) and possibly basal Bajocian (Discites Zone) of Luxembourg, NE France (Lorraine) and SW Germany (Ringsheim).

Homaloteuthis spinata (Quenstedt, 1848) (Pl. 5, figs. 1-4; Figs. 6a, h)

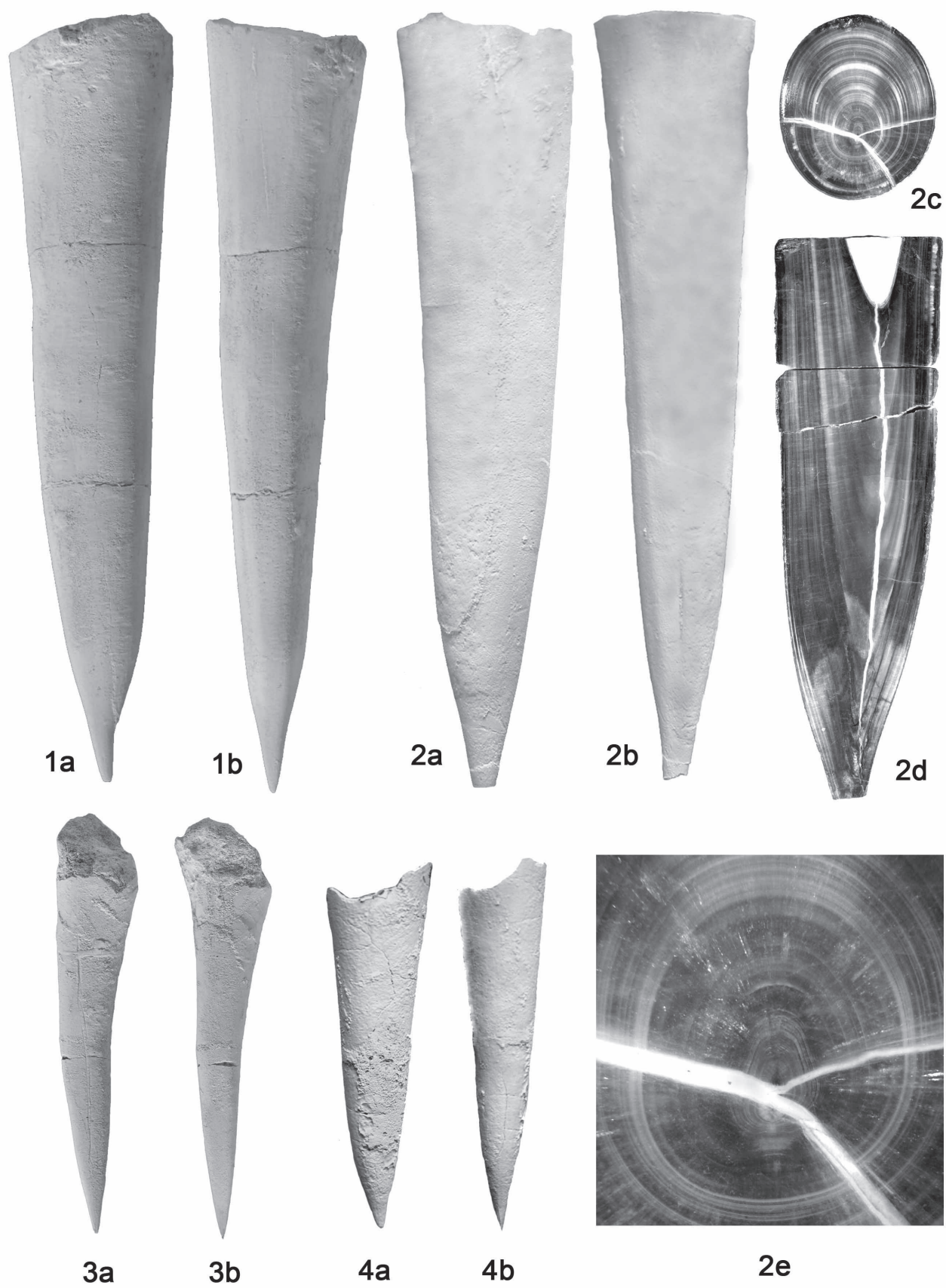
- 1831 *Belemnites elongatus* Miller - v. ZIETEN, p. 28 Pl. 22, fig. 6.
- *v 1848 *Belemnites spinatus* Quenstedt, p. 425. Pl. 27, figs. 7-8.
- pars 1856 *Belemnites spinatus* Quenstedt, p. 351, Pl. 47, fig. 16 (not fig. 15 = *Mesoteuthis rhenana* (Oppel)).
- non 1878 *Belemnites spinatus* Quenstedt - EUDES-DESLONGCHAMPS, p. 44, Pl. 4, figs. 3-10, 13-14 (= *Brevibelus breviformis*, compressed variant).
- 1910 *Belemnites spinatus* Quenstedt - FRAAS, p. 183, Pl. 55, fig. 14.
- 1912 *Belemnites spinatus* Quenstedt - WERNER, p. 139.
- v. 1971 *Belemnites spinatus* Quenstedt - SCHWEGLER, p. 104, text-figs. 112a-d.
- 1980 *Homaloteuthis spinata* (Quenstedt) - RIEGRAF, p. 153.
- ? 1997 *Homaloteuthis spinatus* (Quenstedt) - COMBÉMOREL, Pl. 27, fig. 18.
- v. 1998 *Homaloteuthis spinata* (Quenstedt) - SCHLEGELMILCH, p. 69, Pl. 12, fig. 12.

EXPLANATION OF PLATE 5

figs. 1-3 - *Homaloteuthis spinata* (Quenstedt, 1848).

- 1 - Holotype, adult specimen, Aalenian, Murchisonae Zone, Aalen-Wasseraalfingen/SW-Germany, IGMT Quenstedt 1848 Pl. 27, fig. 8. Lateral (1a) and ventral (1b) views, x 1.
- 2 - Adult specimen with pathological ventral furrow (healed injury), Aalenian, Murchisonae Zone, Aalen-Wasseraalfingen/SW-Germany, MB C.3782.1. Lateral (2a) and ventral (2b) views, x 1; transverse section (2c), x 1.4; longitudinal section (2d), x 1.3; detail of fig. 2c (2e), x 5.5.
- 3 - Juvenile specimen, original of Schwegler 1971, text-fig. 112d, Aalenian, Murchisonae Zone, Aalen-Wasseraalfingen/SW-Germany, IGMT Schwegler 1971 fig. 112b. Lateral (3a) and ventral (3b) views, x 1.

fig. 4 - *Homaloteuthis* cf. *spinata* (Quenstedt, 1848). Juvenile specimen, Aalenian, Murchisonae Zone, Rumelange/Luxembourg, MnhnL HU347. Lateral (4a) and ventral (4b) views, x 1.



Material - Ten specimens from the Murchisonae Zone of Aalen-Wasseraufingen/SW-Germany (IGMT: original to Schwegler, 1971, fig. 112b; Original to Quenstedt, 1848 - MB: C.3781, C.3782.1 - SMNS: 66252, 66257, 66249/2-4 - MnhnL: DOT178, former Riegraf collection WR 729), two specimens cf. *spinata* from the Murchisonae Zone of Rumelange/Luxembourg (MnhnL HU347 and coll. Gross, without label).

Diagnosis - Medium to large sized, robust *Homaloteuthis*. Outline asymmetrical, conical. Profile asymmetrical, cylindriconeal or conical. The apex is acute or mucronate. Transverse sections elliptical. No apical grooves developed.

Description - Large or medium-sized, robust rostra that are commonly conical. Both outline and profile are asymmetrical and conical, the profile being generally more cylindriconeal than the outline. The apical region is short, acute and very characteristic by an asymmetric spine-like ("spinatus") extremity, which develops at the adult stage. There are neither apical grooves nor striae. The transverse section is elliptical and considerably compressed: the extreme compression in the stem region is considerably attenuated in the alveolar region. A "trumpet-like" ending of the alveolar region seems characteristic of the species, due to a considerably thick phragmocone. The phragmocone penetrates approximately one third of the rostrum and is considerably displaced towards the venter.

Ontogeny - The primordial rostrum has a triangular transverse section, with dorsolateral depressions and a marked ventral depression (Pl. 5, fig. 2e; Fig. 6a), similar to the earliest stages of juvenile *Eocylindroteuthis*. This hints to a possible phylogenetic relationship. Juvenile *H. spinata* are conical in shape, slender than adults with an acute but not mucronate apex (Pl. 5, fig. 4). The characteristic spine-like apex develops with the adult stage, which is furthermore characterised by a decrease of length growth and a simultaneously increase of width, determining the robust cylindriconeal profile (Fig. 6h).

Remarks - In previous works, *H. spinata* was sometimes confused with compressed variants of *Brevibelus breviformis* (Eudes-Deslongchamps, 1875), from which it is chiefly distinguished by the robust, large rostrum, a more acute apex and a compressed transverse section. *H. murielae* differs by a different, more elongated apical region, a less conical and slender shape, a lesser penetration of the phragmocone and a regular ontogeny.

Robust adult *Eocylindroteuthis corneliaschmittae* may be confused with *H. spinata*, especially when the ventral depression is weakly developed or not well distinguishable due to a poor conservation in the Bajocian limestones. It however may be distinguished by a different apical region, a more cylindriconeal profile, and the study of the transverse section (Fig. 6).

Schwegler (1971) described some rostra with a ventral, intermediate depression or groove. This feature could not be observed in the studied material, except in the primordial rostrum, showing a ventral depression, which is completely lost in adults. The irregular "groove" in one figured specimen (Pl. 5, fig. 2) is most likely due to a bite of a predator (communicated by W. Riegraf in 2007), a common feature among Jurassic belemnites.

Until now, true *H. spinata* have been reported only from the Upper Aalenian Murchisonae Zone of Southwest Germany (and especially the area around Aalen-Wasseraufingen). Although Benecke (1905, p. 297) stressed it is "most likely a Swabian endemic form with restricted distribution", some authors interpreted it much less restrictively. The species could not yet be identified with certainty from other localities outside of its type area (Aalen-Wasseraufingen). Two specimens, however, from the Luxembourgian Murchisonae Zone referred herein to as *H. cf. spinata*, could represent juveniles of true *H. spinata* (Pl. 5, fig. 4).

The well-preserved, complete and large phragmocones of the present species coming from the reddish Aalen-Wasseraufingen iron ore gave reason to Ehrhart (1724, 1727, p. 5, Pl. 1, fig. 8a) to assign the strange figures stones to Mollusca. The species is, therefore, among the oldest known and figured belemnite species described in literature.

Stratigraphic range and geographical distribution - Upper Aalenian (Murchisonae Zone) of SW Germany (Aalen-Wasseraufingen) and possibly Luxembourg.

Genus *Megateuthis* Bayle, 1878

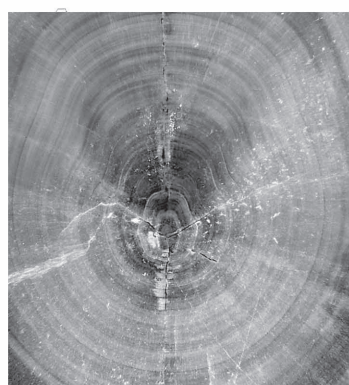
Diagnosis - Very large conical to elongate cylindriconeal Megateuthididae, with a well-developed epistrophum. The outline and profile are symmetrical and conical to cylindriconeal. The apex is obtuse, bears dorsolateral grooves and generally well-marked striae. Transverse sections are compressed and elliptical.

Type species - *Belemnites giganteus* v. Schlotheim, 1820 (= *Belemnites Aalensis* Voltz, 1830) by subsequent designation (Douvillé, 1879, p. 91).

EXPLANATION OF PLATE 6

figs. 1-3 - *Megateuthis suevica* (Klein, 1773).

- 1 - Longitudinal section of an adult specimen with broken epistrophum, Bajocian, Humphriesianum Zone, Rumelange/Luxembourg, MnhnL BM350 (x 1).
- 2 - Sub-adult specimen without epistrophum, Bajocian, Humphriesianum Zone, Rumelange/Luxembourg, MnhnL BM364. Lateral (2a) and ventral (2b) views, x 1.
- 3 - Detail of a transverse section of the rostrum solidum just behind the alveolus, Bajocian, Humphriesianum Zone, Rumelange/Luxembourg, MnhnL BM466 (x 4).



Megateuthis elliptica (Miller, 1826)
(Pl. 7, fig. 1)

- * 1826 *Belemnites ellipticus* MILLER, p. 60, Pl. 8, figs. 14-17.
- v. 2005 *Megateuthis elliptica* (Miller) - WEIS & GROSS, p. 71, text-figs. A2, A11.
- v. 2006 *Megateuthis elliptica* (Miller) - WEIS, p. 157, figs. 9-10 (*cum syn.*).

Material - One specimen from the Laeviuscula or Propinquans Zone of the Motorway A8 at the Aichelberg/SW-Germany (SMNS 66251), one specimen from the Propinquans Zone of Öschingen near Tübingen/SW-Germany (MnhnL DOT179, former Riegraf collection WR 7492), six specimens from the Humphriesianum Zone of Rumelange/Luxembourg (MnhnL BM139, BM287, BM331, BM337, BM342, BM352).

Diagnosis - Large sized cylindriconal *Megateuthis*. Both profile and outline symmetrical and cylindriconal. Apex acute with two dorsolateral grooves. Transverse section elliptical. Epirostrum well developed.

Description - Large, slender, cylindriconal *Megateuthis* generally reaching giant dimensions (Westphalia, NW Germany: length 60-70 cm) at the adult stage, being the longest belemnite species known at all. Both profile and outline are symmetrical or nearly symmetrical and cylindriconal. The apical region is elongated and characterised by an epirostrum, which appears only in longitudinal sections and is not observable in the outline. Two dorsolateral grooves are present on the apex of the orthorostrum and continue on the epirostrum, which generally shows additional irregular striae. The transverse section of the orthorostrum is compressed elliptical, the transverse section of the epirostrum is highly compressed and resembles an "8", due to very incised dorsolaterally placed grooves. A flattened venter is not observed in present species.

Ontogeny - Juvenile forms are regular conical and show weakly developed dorsolateral grooves or depressions. With the subsequent stages they become more cylindriconal. The ontogeny is regular; the passage from ortho- to epirostrum is continuous. The adult stage develops an epirostrum, which approximately occupies one fifth of the whole rostrum.

Remarks - *M. elliptica* is close to *M. suevica* but the latter is more robust, has a more obvious epirostrum and an asymmetric profile, due to an inflated venter. Juveniles of *M. elliptica* approach slender forms of *Eocylindroteuthis corneliaschmittae* in shape, but differ by their dorsolateral grooves, lack of a ventral depression or flattening, and a well-developed epirostrum.

The specific characters are not fully developed in specimens from the Laeviuscula and Propinquans Zone, which reach only about approximately 25 cm whilst the specimens from the Humphriesianum Zone have better developed grooves and span 60-70 cm in length.

Stratigraphic range and geographical distribution - Bajocian (Propinquans to Parkinsoni Zone) of Europe.

Megateuthis suevica (Klein, 1773)
(Pl. 6, figs. 1-3; Figs. 6c, f)

- * 1773 *Belemnites suevicus* KLEIN, p. 27-28, Pl. 7, figs. 2-3.
- v. 1820 *Belemnites giganteus* VON SCHLOTHEIM, p. 45-46.
- 1830 *Belemnites aalensis* VOLTZ, p. 60-62, Pl. 4; Pl. 7, fig. 1.
- 2001 *Megateuthis suevica* (Klein) - RIEGRAF, p. 289-291, figs. 11-12, 19 (*cum syn.*).
- v. 2005 *Megateuthis suevica* (Klein) - WEIS & GROSS, p. 70, text-figs. A1, A10.
- v. 2006 *Megateuthis suevica* (Klein) - WEIS, p. 156, figs. 5-8.

Material - One specimen from the ?Propinquans Zone of Differdange/Luxembourg (MnhnL BU211), one specimen cf. *suevica* from the Laeviuscula Zone of Rumelange/Luxembourg (MnhnL BU260), one specimen from the Propinquans Zone of Eningen bei Reutlingen/SW-Germany (WR 7491), twelve specimens from the Humphriesianum Zone of Rumelange/Luxembourg (MnhnL BM205, BM226-227, BM229, BM281-282, BM332, BM336, BM346, BM349-350, BM364, BM466).

Diagnosis - Large sized conical *Megateuthis*. Profile asymmetrical and conical. Outline symmetrical and cylindriconal to conical. Apex obtuse, striated and with two dorsolateral grooves or depressions. Transverse section elliptical. Well-developed epirostrum.

Description - Large, robust, conical or cylindriconal rostrum, reaching giant dimensions at the adult stage. The profile is asymmetrical and conical or slightly cylindriconal, the outline symmetrical and conical or cylindriconal. The apical region of the orthorostrum is short and starts with an inflated venter. It is furthermore characterised by dorsolateral depressions or grooves and an obtuse striated apex. The well-developed epirostrum shows two dorsolateral grooves and several secondary striae, which can cover up to the entire epirostrum in some cases. However, adult stages are often found without epirostrum (Pl. 6, fig. 2), which led to some confusion in early taxonomic works. The transverse section of the orthorostrum is compressed elliptical, the transverse section of the epirostrum being generally more compressed. The phragmocone is ventrally displaced and penetrates approximately two fifths of the orthorostrum.

Ontogeny - In contrast to *M. elliptica*, the ontogeny of *M. suevica* is irregular. The juveniles are short cones with shallow dorsolateral grooves (Fig. 6c) and an inflated venter. At the sub-adult stage, an epirostrum is developed (Pl. 6, fig. 1; Fig. 6f) which can occupy half of the rostrum in adults.

Remarks - *M. suevica* is very close to *M. elliptica* but differs from the latter in having a more robust, conical orthorostrum with an asymmetric profile, due to the inflated venter. The epirostrum is apparent in the profile and occupies a more important part of the rostrum in *M. suevica*. Juveniles can be confused with juveniles of *Eocylindroteuthis*, which show a similar conical profile but lack any apical dorsolateral grooves, developing an intermediate ventral depression instead.

As seen in *M. elliptica*, the specimens of *M. suevica* from the Propinquans Zone do not reach the giant dimensions of rostra from the Humphriesianum Zone.

Stratigraphic range and geographical distribution - Lower Bajocian (Propinquans to ?Parkinsoni Zone) of NE and central France (Great Britain, Lorraine, Alsace, Vallée-du Rhône, Mont d'Or), Luxembourg, SW Germany, Franconia, NW Germany (Westphalia), and Lower Saxony.

Genus *Mesoteuthis* Lissajous, 1915

Diagnosis - Medium to large sized conical or cylindriconeal Megateuthidae without epirostrum s. s. Profile asymmetrical cylindriconeal. Outline symmetrical conical to cylindriconeal. Transverse sections elliptical compressed. Two dorsolateral apical grooves. Apical line diffuse.

Type species - *Belemnites rhenanus* Oppel, 1856.

Mesoteuthis beneckeii (Schwegler, 1938)
(Pl. 7, figs. 2-3)

- v.* 1938 *Megateuthis beneckeii* SCHWEGLER, p. 462, text-fig. 1.
- v. 1965 *Belemnites (Megateuthis) beneckeii* SCHWEGLER, p. 92, text-fig. 58.
- 1980 *Megateuthis (Mesoteuthis) beneckeii* Schwegler - RIEGRAF, p. 147, tab.2.
- 1995 *Megateuthis beneckeii* Schwegler - RIEGRAF, p. 52.
- 1997 *Megateuthis beneckeii* Schwegler - COMBÉMOREL, p. 159.
- v. 1998 *Mesoteuthis beneckeii* (Schwegler) - SCHLEGELMILCH, p. 74, Pl. 11, fig. 9, Pl. 14, fig. 1.
- v. 1999 *Mesoteuthis beneckeii* (Schwegler) - WEIS, p. 231, fig. 38.

Material - One specimen cf. *beneckeii* from the Murchisonae Zone of Rumelange/Luxembourg (MnhnL, no registration number), one specimen from the Murchisonae Zone of Aalen-Wasseraffingen/SW-Germany (IGMT, holotype of Schwegler 1938), two specimens from the Murchisonae Zone of Aalen-Wasseraffingen/SW Germany (MB C.3782.2; SMNS 66249/1), three specimens from the Murchisonae Zone of the Schaffberg and the Plettenberg hill near Balingen/SW-Germany (MnhnL DOT181, DOT174, former Riegraf collection WR 7493, 7517, 7518).

Diagnosis - Medium or large sized, cylindriconeal *Mesoteuthis*. Profile asymmetrical, conical to cylindriconeal, outline symmetrical and cylindriconeal. Apex obtuse, two well-developed dorsolateral grooves. Transverse section elliptical, compressed. Apical line diffuse.

Description - Medium or large sized cylindriconeal rostra, slender in the early stages, and robust-elongated in the adult stage. The profile is asymmetrical, conical to cylindriconeal. The outline is symmetrical and cylindriconeal. The apex is generally obtuse, but can be more acute in some specimens. It bears two well-developed dorsolateral grooves, which generally reach one quarter of the total rostrum length. On well-preserved specimens short apical striae can be observed. The

transverse section is elliptical, compressed, in some cases a distinct laterally flattened area, which does not reach the apical region, can be observed in adults. The apical line consists of a diffuse zone.

Ontogeny - Juveniles are slender and already show well-developed apical grooves (Pl. 7, fig. 3). During ontogeny, the rostrum grows both in length and width, which leads to a robust, elongated shape in the adult stage.

Remarks - *Mesoteuthis beneckeii* is most close to *Mesoteuthis rhenana* (Oppel, 1856) from the Upper Toarcian. The latter is, however, less slender during juvenile stages, less compressed and less elongated with shorter dorsolateral apical grooves. *Megateuthis suevica* is distinguished by a more robust rostrum, an inflated venter, less incised dorsolateral apical grooves and a well-developed epirostrum.

Stratigraphic range and geographical distribution - Upper Aalenian (Murchisonae Zone) of SW Germany, Luxembourg, France (Lorraine).

Suborder PACHYBELEMNOPSEINA Riegraf, 1998
Family HOLCOBELIDAE Gustomesov, 1977

Genus *Holcobelus* Stolley, 1927

Diagnosis - Small to medium sized, elongated, conical to cylindrical Holcobelidae. Apex acute or obtuse (orthorostrum). No apical grooves. Intermediate ventral groove. Transverse sections rounded or elliptical, compressed. Epirostrum well developed in some species.

Type species - *Belemnites munieri* Eudes-Deslongchamps, 1878.

Holcobelus blainvillii (Voltz, 1830)
(Pl. 7, figs. 4-6)

- * 1830 *Belemnites blainvillii* VOLTZ, p. 37, Pl. 1, fig. 9.
- v. 1980 *Holcobelus blainvillii* (Voltz) - RIEGRAF, p. 168, text-fig. 152, Pl. 1, figs. 1-5 (*cum syn.*).
- 1998 *Holcobelus blainvillii* (Voltz) - SCHLEGELMILCH, p. 76, Pl. 16, figs. 2-3.
- 1999 *Holcobelus blainvillei* (Voltz) - RIEGRAF, text-fig. 36.

Material - Seven specimens from the Upper Aalenian, Murchisonae Zone, and Concavum Zone from Rumelange/Luxembourg (MnhnL HU210, HU225, HU227, HU286), five specimens from the Discites Zone of the Plettenberg hill near Balingen/SW-Germany (MnhnL DOT175, former Riegraf collection WR 7498-7502), five specimens from the Concavum Zone of Blumberg-Achdorf, Wutach River/SW Germany (MnhnL DOT182, former Riegraf collection WR 7503-7507).

Diagnosis - Small or medium sized *Holcobelus*. Profile symmetrical, conical to cylindriconeal. Outline symmetrical, cylindriconeal. Apex acute. Intermediate ventral groove extending from the apical to the alveolar

region without reaching the extremities. Transverse section rounded or slightly depressed.

Description - Small or medium sized, slender cylindricornal rostra. The profile is symmetrical or slightly asymmetrical, conical to cylindricornal. The outline is symmetrical and cylindricornal. The apical region is elongated, acute and shows neither grooves nor striae. A well-incised intermediate ventral groove extends from the apical region to the alveolar region. This groove can be more incised in some or less incised and broader in other individuals. It fades out on the alveolar region and except for some rare cases does not reach the extremity of the apex. The transverse section is rounded subquadrate, and can be more elliptical and slightly depressed in the apical region.

Ontogeny - Juveniles are similar in shape to adult individuals, but show a less developed ventral groove (Pl. 7, figs. 5-6).

Remarks - *H. blainvillii* is similar in shape to slender variants of *Brevibelus breviformis* but can be easily distinguished by its ventral groove. Other species of *Holcobelus* are less acute and show a longer ventral groove extending towards the extremity of the alveolar region. Furthermore they differ in their conical outline (*H. munieri*, Eudes-Deslongchamps, 1878) or have a shorter apical region and a more cylindrical outline as *H. subblainvillei* (Eudes-Deslongchamps, 1878) and *H. tetramerus* (Eudes-Deslongchamps, 1878).

Stratigraphic range and geographical distribution - Upper Aalenian (Concavum Zone) to Lower Bajocian (Discites Zone) of Luxembourg, France (Normandy, Lorraine), England and SW Germany.

Family MESOHIBOLITHIDAE Nerodenko, 1983

Genus *Hibolithes* Denys de Montfort, 1808

Diagnosis - Elongated, slender Mesohibolithidae. Both profile and outline symmetrical and usually hastate. Maximum transverse diameter usually at the apical region. Transverse section generally circular, in some cases depressed in the apical region in some others compressed in the alveolar region. Shallow ventral canal limited at the anterior half of the rostrum. Well evident lateral lines. Central apical line.

Type species - *Hibolithes hastatus* Denys de Montfort, 1808.

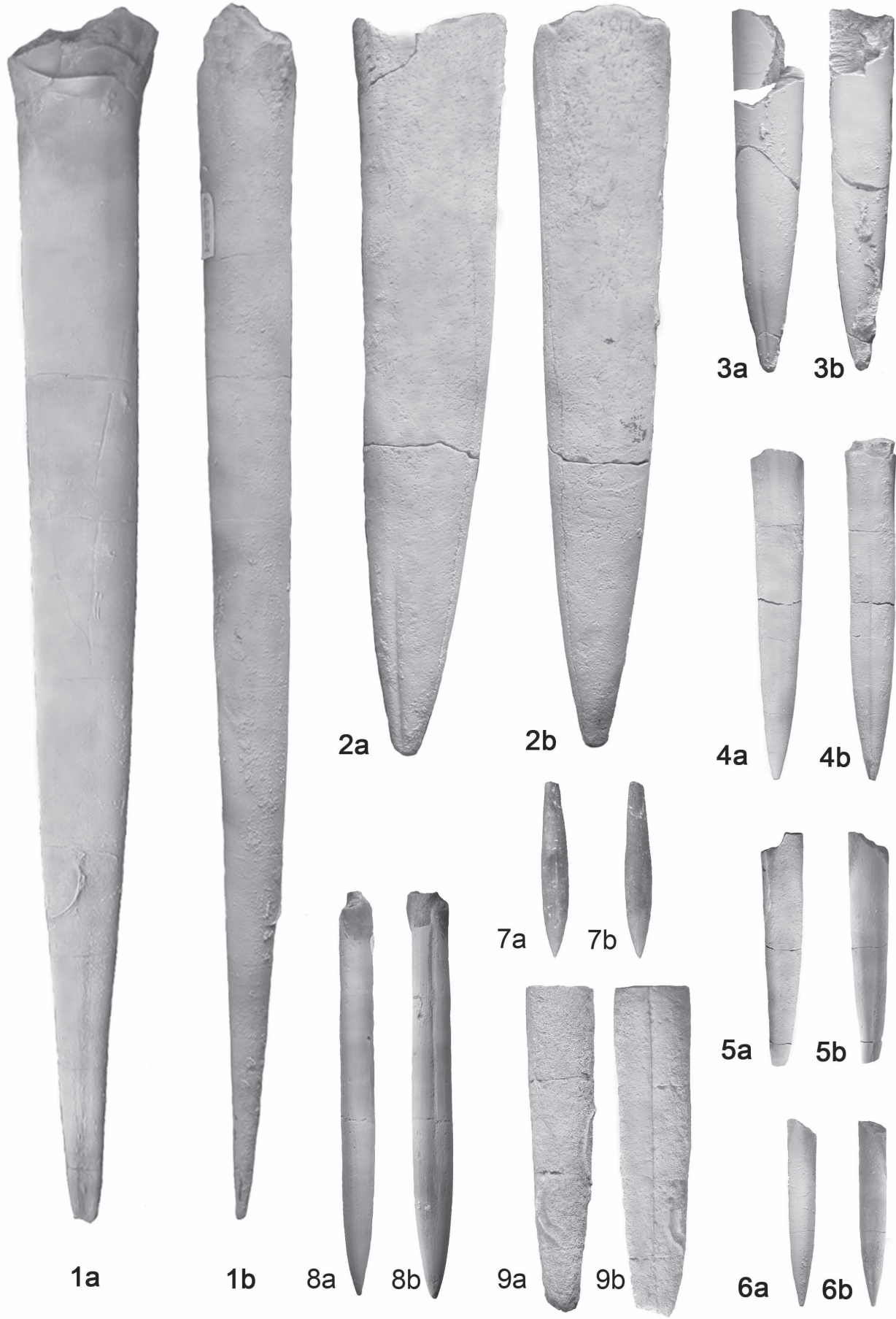
Hibolithes wuerttembergicus (Oppel, 1856)
(Pl. 7, fig. 7)

- * 1856 *Belemnites wuerttembergicus* OPPEL, p. 485.
- 1830 *Actinocamax* cf. *milleri* VOLTZ - v. ZIETEN, p. 33, Pl. 25, fig. 3a.
- 1830 *Actinocamax fusiformis* - v. ZIETEN, p. 33, Pl. 25, fig. 3b.
- 1832 *Actinocamax lanceolatus* Hartmann - v. ZIETEN, p. 33, Pl. 25, figs. 3c-f.
- 1981 *Hibolithes* (*H.*) *wuerttembergicus* (Oppel) - RIEGRAF, p. 67-70, figs. 37-38 (*cum syn.*).
- 1998 *Hibolithes wuerttembergicus* (Opp.) - SCHLEGELMILCH, p. 82, Pl. 18, figs. 6-9, Pl. 20, fig. 14.
- v. 2005 *Hibolithes wuerttembergicus* (Oppel) - WEIS & GROSS, p. 68, fig. A3.
- v. 2006 *Hibolithes wuerttembergicus* (Oppel) - WEIS, p. 161, fig. 11.

Material - Two specimens from the Humphriesianum Zone of Rumelange/Luxembourg (Soirfeck collection, without label).

EXPLANATION OF PLATE 7

- fig. 1 - *Megateuthis elliptica* (Miller, 1826). Sub-adult specimen, Bajocian, Propinquans Zone, Aichelbergaufstieg near Maustobelbrücke/SW Germany, SMNS 66251. Lateral (1a) and ventral (1b) views, x 1.
- figs. 2-3 - *Mesoteuthis beneckeii* (Schwegler, 1938).
 - 2 - Adult specimen, Aalenian, Murchisonae Zone, Aalen-Wasseraufstieg/SW Germany, MB C.3782.2. Lateral (2a) and ventral (2b) views, x 1.
 - 3 - Juvenile specimen, Aalenian, Murchisonae Zone, Plettenberg near Balingen/SW Germany, Riegraf collection WR7518. Lateral (3a) and ventral (3b) views, x 1.
- figs. 4-6 - *Holcobelus blainvillii* (VOLTZ, 1830).
 - 4 - Sub-adult specimen, Bajocian, Discites Zone, Plettenberg b. Balingen/SW-Germany, Riegraf collection WR7498. Lateral (4a) and ventral (4b) views, x 1.
 - 5 - Juvenile specimen, Aalenian, Concavum Zone, Rumelange/Luxembourg, MnhnL HU227. Lateral (5a) and ventral (5b) views, x 1.
 - 6 - Juvenile specimen, Aalenian, Concavum Zone, Rumelange/Luxembourg, MnhnL HU286. Lateral (6a) and ventral (6b) views, x 1.
- fig. 7 - *Hibolithes wuerttembergicus* (Oppel, 1856). Juvenile specimen, Bajocian, Humphriesianum Zone, Rumelange/Luxembourg, Soirfeck collection. Lateral (7a) and ventral (7b) views, x 1.
- fig. 8 - *Pachybelemnopsis roettingensis* (Schlegelmilch, 1998). Sub-adult specimen, Bajocian, Humphriesianum Zone, Rumelange/Luxembourg, MnhnL BM352. Lateral (8a) and ventral (8b) views, x 1.
- fig. 9 - *Pachybelemnopsis baculiformis* Riegraf, 1980. Stem fragment of an adult specimen, Bajocian, Humphriesianum Zone, Rumelange/Luxembourg, Gross Collection. Lateral (9a) and ventral (9b) views, x 1.



Description - Small, hastate rostra. Both profile and outline are symmetrical and hastate. The apex is moderately acute. Lateral lines are well distinguishable.

Remarks - The two specimens are typical of juvenile *Hibolithes* and are referred here to the species *H. wuerttembergicus*, which usually shows a weakly developed ventral alveolar canal. They are synonymous with the juveniles figured by v. Zieten (1832, Pl. 25, figs. 3c-f). In the studied specimens the ventral alveolar canal is not to observe but the frail alveolar region is not completely preserved.

Stratigraphic range and geographical distribution - Bajocian (Humphriesianum Zone) to Bathonian of Europe.

Genus *Pachybelemnopsis* Riegraf, 1980
(pro *Belemnopsis* auct., not Bayle, 1878)

Diagnosis - Cylindrical to hastate, elongate Mesohibolithidae. Outline symmetrical. Profile asymmetrical. Apex acute. Transverse section generally depressed in the apical and stem regions. Broad, ventral alveolar canal extending up to the apex. Apical line ventrally eccentric. Lateral lines rarely present.

Type species - *Belemnites canaliculatus* v. Schlotheim, 1820

Pachybelemnopsis baculiformis Riegraf, 1980
(Pl. 7, fig. 9)

- *v. 1980 *Belemnopsis* (*Pachybelemnopsis*) *baculiformis* RIEGRAF, p. 179-181, text-figs. 160-161, Pl. 1, fig. 11 (*cum syn.*).
- 1980 *Belemnopsis* (*Longibelemnopsis*) *flexuosa* RIEGRAF, p. 191-192, text-figs. 176-177, Pl. 2, fig. 3, Pl. 4, fig. 30 (pathological variant).
- 1998 *Belemnopsis baculiformis* Riegraf - SCHLEGELMILCH, p. 79, Pl. 16, figs. 10-11.
- v. 2006 *Pachybelemnopsis baculiformis* Riegraf - WEIS, p. 161, fig. 12.

Material - One fragmentary specimen from the Humphriesianum Zone of Rumelange/Luxembourg (Collection Gross, without label).

Description - Medium sized, cylindrical rostrum. A ventral canal is extending over the whole fragment, fading out towards the apical region. The alveolar region and the apex are not preserved in this specimen. The transverse section is depressed.

Stratigraphic range and geographical distribution - Lower Bajocian (Humphriesianum Zone) of Luxembourg, NE France and SW Germany.

Pachybelemnopsis roettingensis (Schlegelmilch, 1998)
(Pl. 7, fig. 8)

- v. 1980 *Belemnopsis* (*Longib.*) cf. *beyrichi* (Oppel) - RIEGRAF, p. 188, text-fig. 172, Pl. 2, figs. 20-21.
- * 1998 *Belemnopsis roettingensis* SCHLEGELMILCH, p. 78, Pl. 17, figs. 2-4.

- v. 2005 *Pachybelemnopsis roettingensis* (Schlegelmilch) - WEIS & GROSS, p. 68, text-fig. A5.

- v. 2006 *Pachybelemnopsis roettingensis* (Schlegelmilch) - WEIS, p. 160, fig. 12.

Material - Three specimens from the Humphriesianum Zone of Rumelange/Luxembourg (MnhnL BM321, BM352, BM354)

Diagnosis - Small, slender cylindrical or subhastate *Pachybelemnopsis*. Profile symmetrical and cylindrical, outline symmetrical and subhastate. Apex acute. Ventral alveolar canal. Transverse sections depressed in the apical region, subcircular or compressed in the alveolar region.

Description - Small-sized, slender and gracile rostra. The profile is symmetrical and cylindrical; in some cases it can be slightly subhastate. The outline is symmetrical and subhastate. The apical region is short and acute. The well-incised ventral alveolar canal extends from the extremity of the alveolar region towards the apical region. It generally fades out before reaching the apex at the point where the apical region is most depressed. In juveniles it is usually shorter and may just reach half of the rostrum. Transverse sections of the rostrum are depressed in the stem- and especially the apical-region, but rounded or compressed in the alveolar region.

Ontogeny - Juveniles consist of small, frail rostra, which are generally more cylindrical in outline than adults. The alveolar ventral canal does not reach the apical region.

Remarks - Not possessing a very characteristic shape, *P. roettingensis* differs from *P. baculiformis* mainly by its slender and smaller rostrum. It might represent the juvenile stage of the latter one (Riegraf, 2007, pers. comm.); however, an ontogenetic study was not possible for the present work due to the scarcity of the available material.

Stratigraphic range and geographical distribution - Lower Bajocian (Humphriesianum Zone) of Luxembourg, NE France and SW Germany.

PALEOBIOGEOGRAPHIC REMARKS

The order Belemnitida in the Hettangian-Pliensbachian is restricted to Europe, Turkey, Greenland, and northern Africa. The Belemnitida penetrated into northern Siberia during the Toarcian, forming an endemic fauna during Toarcian/Aalenian (Sachs & Nalnjajeva, 1970, 1975). From Siberia via the Arctic seas they penetrated into Arctic Canada, also forming an endemic fauna (Jeletzky, 1980). Across Europe, the Lower Jurassic belemnite faunas show a markedly similar composition (Doyle, 1987). The Bajocian transgression caused a diversification of the marine invertebrate faunas, resulting in separate Boreal and Mediterranean provinces, where Germany is an important transitional area (Riegraf, 2007, pers. comm.).

Normandy (France) plays an important role for our understanding of the early Middle Jurassic belemnite distribution, due to its peculiar fauna, which is dominated

by several species of the genus *Holcobelus* (Eudes-Deslongchamps, 1878; Stolley, 1927). It would be most important to revise these faunas using a modern taxonomic approach, in order to define more precisely the stratigraphic and geographic distribution of the different species. A very similar but yet undescribed fauna was found in Haute Provence (France), where outcrops along the Lac du Castillon near Castellane (Riegraf collection, and own field observations) and at the Truc de Balduc near Mende (Département de la Lozère; Riegraf, 1980, p. 39) yield a very similar *Holcobelus*-dominated fauna.

Therefore *Holcobelus* may be the genus marking the passage from a Lower Jurassic uniform Europe-wide belemnite fauna towards the development of endemism and the establishment of a Tethyan fauna (Combémourel et al., 1994, p. 49).

In western and central Europe (except Normandy), during the early Middle Jurassic, we see a predominance of Megateuthidae (*Brevibelus*, *Megateuthis*, *Homaloteuthis*) and Cyliindroteuthidae (*Eocyliindroteuthis*), with Holcobelidae, represented by the single species *Holcobelus blainvillii* playing a minor role compared to Normandy. In this context, the faunas of SW Germany and Luxembourg show strong relationships during the Late Aalenian and the Early Bajocian (Tab. 1). Unfortunately, in southern Germany Aalenian and Lower Bajocian belemnites are quite rare or lacking, except the basal Opalinum Zone and some local oolitic ammonite-

bearing beds (Comptum Subzone, Concavum Zone, Discites Zone), due to unfossiliferous uniform fine-grained claystones, sandstones, and sandy marlstones. Often the ammonite-bearing beds are so hard that the rare belemnite rostra cannot be prepared. The same situation was observed at Truc de Balduc (Département de la Lozère) in southern France, where thick Lower Toarcian to Upper Aalenian clay- and marlstones do not yield belemnites at all, except for some meters in the Bifrons and Aalensis Zones. Due to these facts the phylogeny of the belemnites of those intervals cannot be reconstructed in both regions (Riegraf, 2007, pers. comm.). The belemnite rostra described in present paper from Luxembourg will contribute to close this gap in phylogeny.

In contrast to western and central Europe, the early Middle Jurassic Mediterranean area is characterised by the families Mesohibolothidae and Holcobelidae and by rare megateuthid forms (*Megateuthis* and *Brevibelus*; Stoyanova-Vergilova, 1990; Mariotti et al., 2007). *Pachybelemnopsis* appears in western and central Europe in large numbers in the Humphriesianum Zone (Riegraf, 1980; Weis, 2006), soon followed by the first *Hibolites*. In western and central Europe the Humphriesianum Zone marks the faunistic changeover point with the decline of the suborder Belemnitina, with *Megateuthis* and *Brevibelus* surviving throughout the final Bajocian, and the rise of the Tethyan *Pachybelemnopsis* with a massive presence of *Pachybelemnopsis* and *Hibolites*.

Stage	Ammonite Zone	<i>Eocyliindroteuthis corneliaschmittae</i>	<i>Eocyliindroteuthis trautscholdi</i>	<i>Eocyliindroteuthis brevispinata</i>	<i>Brevibelus breviformis</i>	<i>Brevibelus gingensis</i>	<i>Homaloteuthis murelae</i>	<i>Homaloteuthis spinata</i>	<i>Mesoteuthis beneckeii</i>	<i>Megateuthis elliptica</i>	<i>Megateuthis suevica</i>	<i>Holcobelus blainvillii</i>	<i>Hibolites wuerttembergicus</i>	<i>Pachybelemnopsis roettingensis</i>	<i>Pachybelemnopsis baculiformis</i>
Bajocian	Humphriesianum														
	Propinquans														
	Laeviuscula														
	Discites														
Aalenian	Concavum														
	Murchisonae														

Tab. 1 - Stratigraphic distribution of belemnite species at the Aalenian-Bajocian boundary in Luxembourg (marked by a continuous line) and SW Germany (marked by a dashed line).

CONCLUSIONS

Belemnite assemblages from the Aalenian-Bajocian boundary are particularly interesting to understand the development of belemnite provincialism in the European Jurassic. Unfortunately, several belemnite species have never been sufficiently characterized which caused some confusion in previous works. The present work revises the previously known species from Luxembourg and Germany, based on the type material and comparative rostra from both historical and present-day outcrops. Ontogenetic investigation permitted to erect a new species, *Homaloteuthis murielae* n.sp., that is predominant in Aalenian outcrops in Luxembourg.

The taxonomic results demonstrates that during the Late Aalenian and Early Bajocian the faunas of Luxembourg and SW Germany were almost identical. The characteristic genera for both areas include *Brevibelus*, *Mesoteuthis*, *Holcobelus*, and *Homaloteuthis* for the Upper Aalenian and *Eocylindroteuthis*, *Brevibelus*, and *Megateuthis* for the Lower Bajocian. Together with data gathered from literature it can be affirmed that the western and central European fauna (Germany, Luxembourg, NE France, Switzerland and Austria) is largely dominated by taxa from the suborder Belemnitina whilst comparable faunas of Aalenian-Bajocian age from southern Italy (Combémoré et al., 1994) show a strong predominance of *Pachybelemnopsis*. In Luxembourg and SW Germany, this faunal composition clearly changes during the Bajocian Humphriesianum Zone with the rise of the genera *Pachybelemnopsis* and *Hibolithes* in that area.

More detailed paleobiogeographic considerations will be carried out in a synoptic paper treating European Aalenian-Bajocian belemnite faunas (Mariotti et al., 2007).

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