Belemnitellid coleoids (Mollusca, Cephalopoda) from the type Maastrichtian, the Netherlands and Belgium

J.W.M. Jagt

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John W.M. Jagt, Natuurhistorisch Museum Maastricht, de Bosquetplein 6-7, NL-6211 KJ Maastricht, the Netherlands (john.jagt@maastricht.nl).

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Belemnitellid coleoids abound at some levels within the Gulpen and Maastricht formations in the study area, and 'belemnite graveyards' have long been known from the Bovenste Bos (Epen) and Slenaken-Beutenaken areas in southern Limburg, the Netherlands. Recent studies have demonstrated the presence of at least three species of the genus *Belemnitella* d'Orbigny, 1840, and five of *Belemnella* Nowak, 1913, and its subgenera *Belemnella*, *Pachybelemnella* Schulz, 1979, and *Neobelemnella* Naidin, 1975. Representatives of *Belemnitella junior* Nowak, 1913, and *Belemnella* (*Neobelemnella*) gr. *kazimiroviensis* (Skołozdrówna, 1932) are the only coleoids to reach the Cretaceous-Paleogene (K/Pg) boundary, and members of the latter group may even have persisted into the earliest Paleocene.

Contents

Introduction

The sturdy, well-calcified rostra of squid have long been known from the study area in southern Limburg (the Netherlands), and contiguous Belgian and German territories. As far as I have been able to establish, such were first well illustrated and briefly, yet accurately, described by Faujas Saint Fond (1799-1803?), who did not use Latin binomial names for them. It was von Schlotheim (1813) who erected the names *Belemnites mucronatus* and *Belemnites lanceolatus* (for details, see Riegraf, 2001). However, it should be noted that subsequent scholars, more or less routinely, referred to nearly all Late Cretaceous belemnitellids from Europe, including the ones from the type area of the Maastrichtian Stage, by those names only, and that external morphology was the prime distinctive feature accepted. Binkhorst van den Binkhorst (1861) followed suite and lumped all under the name *Belemnitella mucronata* d'Orbigny [*sic*]. Most of the specimens illustrated by that author, in beautiful engravings, can now easily be identified as *Belemnitella junior* (see below).

Belemnite studies did not flourish until scientists in parts of the former Soviet Union (Russia and Ukraine) came to realise that various species and subspecies could be distinguished, and that those forms were of prime stratigraphic value, in particular in the late Campanian and Maastrichtian, that is, the youngest 10 myr of the Cretaceous Period (Arkhangelsky, 1912). Continuing along these lines, Jeletzky (1948, 1949, 1951) introduced a standardisation which led to a better understanding of genera, species and subspecies, and the biozones based on these. This method was widely adopted and Naidin (1952, 1964, 1975), in particular, described numerous new taxa from Cretaceous strata in the former Soviet Union, although his way of working met with criticism from colleagues in western and northern Europe.

For the type area of the Maastrichtian, work by Jeletzky (1951) and Birkelund (1957) is of fundamental importance. The first demonstrated that *Belemnitella junior* (and 'subspecies' *nowaki* Jeletzky, 1951) had routinely (yet erroneously) been referred to by previous generations as *Belemnitella mucronata*, and that that species was widely distributed in the type area, while Birkelund (1957, pl. 6, fig. 6) recorded *Belemnella casimirovensis* (= *Belemnella kazimiroviensis*, as here understood) from Geulhem for the first time, on the basis of a single rostrum cavum. Subsequently, Schmid (1959, 1967) much improved our knowledge by meticulous collecting at all outcrops of Campanian and Maastrichtian strata in the study area between Liège, Maastricht and Aachen. By and large, his subdivision still stands, although it has been much refined during the past twenty years. A number of authors have also recorded species that had not been previously recognised in the area or presented general overviews (Christensen & Schmid, 1987; Van der Tuuk & Bor, 1980; Keutgen & Van der Tuuk, 1991; Keutgen, 1996, 1997, 2011; Jagt *et al*., 1995; Jagt, 1996; Keutgen & Jagt, 1999; Christensen *et al*., 2004; Keutgen *et al*., 2010).

Palaeo(bio)geographically, southern Limburg and contiguous areas belonged to the North European Province during the Late Cretaceous, which extended from Ireland to east of the Ural Mountains in Russia (Christensen, 1975, 1997a). During the early Campanian (*c*. 83.5-81 Ma) a Central-European Subprovince can be distinguished, which is characterised by the occurrence of the genera *Actinocamax* Miller, 1823 [not in the study area], *Gonioteuthis* Bayle, 1878, and *Belemnitella*. In particular, the succession of species and subspecies of *Gonioteuthis* has proved of seminal importance for the zonation of the early Campanian (Christensen, 1996, 1997a, b). Predominant in the late Campanian (81-76 Ma) was the genus *Belemnitella*, which, in part, was linked to the demise of other forms, such as *Actinocamax*, *Gonioteuthis* and *Belemnellocamax* Naidin, 1964, around the early/late Campanian boundary. Numerous species, primarily in northwest Europe, have been distinguished in the late Campanian interval, some of which are widely distributed (Christensen *et al*., 1975; Schulz & Schmid, 1983; Christensen, 1987, 1999), while others illustrate a tendency for the development of regional species (Christensen, 1986, 1993, 1995, 1998, 2000a, b, 2002).

Just below the late Campanian/early Maastrichtian boundary, a new belemnitellid 'revolution' is seen; the successful genus *Belemnella* (subgenera *Belemnella* and *Pachybelemnella*) first appeared. Various species are characteristic of the latest Campanian and the whole of the early Maastrichtian (Schulz, 1979; Keutgen, 1996, 1997; Christensen, 1999; Remin, in press), although a certain number of species of the genus *Belemnitella* at times co-occur (Schulz, 1982). Also during this interval, a migration occurred of *Belemnella praearkhangelskii* from the westerly part of the Russian Platform, which has been recorded from northern Germany, the Voer area (northeast Belgium) and Denmark (Schulz, 1979; Keutgen, 1997). Across the early/late Maastrichtian boundary, the picture changed anew: *Belemnitella* of the *junior* group ousted *Belemnella* and expanded its distributional area from northwest Europe to Poland, the western Ukraine and Crimea, and as far east as Azerbaijan (Caucasus) and the northern part of Tethys, the precursor of the Mediterranean. Only in the latest Maastrichtian does the subgenus *Belemnella* (*Neobelemnella*) succeed in extending its area, from its place of origin in the eastern part of the Russian Platform, in a westerly direction, as finds from Poland, Denmark and the Maastricht area demonstrate (Birkelund, 1957; Schmid, 1967; Van der Tuuk & Bor, 1980; Jagt, 1996). There appears to be a general consensus that belemnitellids went extinct at the Cretaceous-Paleogene (K/Pg) boundary, although in the Geulhem area (southern Limburg, the Netherlands) finds of *Belemnella* (*N.*) gr. *kazimiroviensis* have been made at the base of the Geulhem Member (early Paleocene) which show hardly any traces of abrasion, suggestive of resedimentation. Hopefully, isotope analysis can help in elucidating this matter in the near future.

Lastly, the issue of 'belemnite battlefields' requires discussion. Doyle & MacDonald (1993) distinguished various types of concentrations of rostra and tried to come up with biological (spawning and subsequent mass death) and sedimentological explanations. For the study area, the occurrence of this kind of lag deposits has been recorded from the Vijlen Member (Keutgen & Van der Tuuk, 1991; Keutgen, 1996; Keutgen *et al*., 2010), from the basal Valkenburg Member (just above the Lichtenberg Horizon) and the basal Geulhem Member (Houthem Formation), directly on top of the K/Pg boundary from the Geulhem/Berg en Terblijt area (southern Limburg, the Netherlands), and also the Albert Canal between Vroenhoven and Veldwezelt (Limburg, northeast Belgium; Van der Tuuk & Bor, 1980; Jagt, 1996). In particular for the Vijlen Member, Keutgen *et al*. (2010) have recently demonstrated that resedimentation was the rule, rather than exception, during deposition of that unit and that, therefore, the early Maastrichtian belemnite zones described by Schulz (1979) for northern Germany could only be recognised with difficulty in the study area, because remanié assemblages generally contain more than one species of *Belemnella*.

Material and methods

Paradoxically, the identification of belemnitellids from Late Cretaceous strata in the Maastrichtian type area is not at all straightforward, at least in the majority of cases. Although detailed studies during the last twenty years suggest otherwise, it is a time-consuming exercise with a lot of pitfalls. Analyses generally rely on 'populations', that is, sets of between 25 and 50 specimens (preferably more) from a restricted stratigraphical interval (mostly 0.5 to 1.5 m thickness), for which all kinds of external and internal features (see Fig. 1) are measured and computed. These measurements are then analysed statistically and plotted in graphs (Christensen, 1975; Schulz, 1979, 1982; Keutgen *et al*., 2010).

This, of course, implies that the identification to species of a single rostrum can only be done with certain reservations, although belemnite workers, after long years of experience, may be expected to be able to tell species apart exclusively on external characters. In that respect, the pattern of blood vessels (vascularisation), the course of the dorsolateral double furrows and the presence or absence of 'pseudogranulation' or longitudinal striae are of importance. A subsequent check of internal features, after splitting the rostrum along the ventral fissure, can then corroborate or refute the preliminary identification.

The splitting of the rostrum (see Fig. 1) is a requirement for the genera *Belemnitella* and *Belemnella*, so as to document a number of measurements, for example, Ls, AA, FA and SD (see below). The rostrum generally is (secondarily) calcified so that, starting at the ventral fissure, a thin line is visible (hold against the light), which subdivides the rostrum into two equal halves. With the help of a thin chisel and a light hammer the rostrum can be split; a few minutes in boiling water can help in some cases to facilitate splitting. In most cases, this can be easily done (even in the field), but leaves the rostrum destroyed. Following measuring, the two halves can either be left as is, or glued back together again.

In order to tell the various species of the genera *Belemnitella* and *Belemnella* apart, the splitting of the rostrum is a prerequisite. Particularly, species of the same evolutionary lineage often differ only in minor details, for instance, *Belemnitella praecursor*, *Belemnitella mucronata*, *Belemnitella woodi* and *Belemnitella* cf. *minor* II. In addition, especially in the Vijlen Member, resedimentation tends to blur the picture. As far as the genus *Belemnella* is concerned, the detailed biozonal scheme developed by Schulz (1979) can rarely, or at best with great difficulty, be recognised in the study area, which explains why the belemnite biostratigraphy of the lower portion of the Vijlen Member (intervals 0-3) is comparatively poorly known.

Although Late Cretaceous belemnitellids still play a great role in biostratigraphy, as index fossils, in recent years it has become clear that distribution patterns (both geographical and stratigraphical) of the various species need to be re-evaluated. These differences are possibly related to palaeoecological and palaeocli-

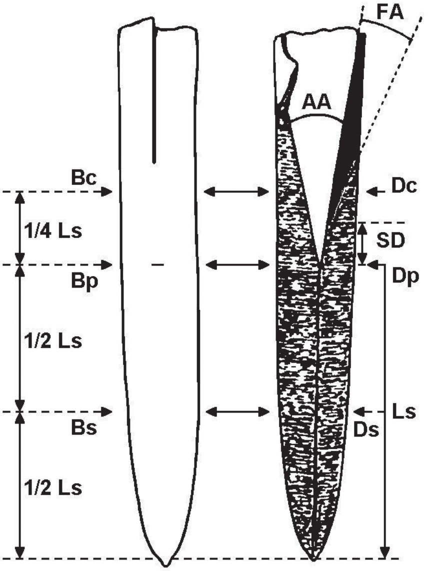

Fig. 1. Terminology of a belemnitellid guard, in ventral view and split longitudinally to show internal features; abbreviations are as follows: Bs – lateral diameter halfway between apex and protoconch (in mm); Bp – lateral diameter at protoconch (in mm); Bc – lateral diameter at rostrum cavum, one quarter Ls from protoconch (in mm); Ds – dorsoventral diameter halfway between apex and protoconch (in mm); Dp – dorsoventral diameter at protoconch (in mm); Dc – dorsoventral diameter at rostrum cavum, one quarter Ls from protoconch (in mm); Qp – Bp/Dp; Ls – length from apex to protoconch (in mm); BI – Birkelund Index (BI = Ls/Dp); AV – ventral aspect (AV = (Bs-Bc) × 100/Bp in per cent); AL – lateral aspect (AL = (Ds-Dc) × 100/Dp in per cent); AVs – ventral aspect of rostrum solidum (AVs = (Bs-Bp) × 100/Bp in per cent); ALs = lateral aspect of rostrum solidum (ALs = (Ds-Dp) × 100/Dp in per cent); SD – Schatzky Distance, distance (in mm) between anterior part of protoconch and posterior end of ventral fissure measured along guard axis; AA – alveolar angle, being dorsoventral angle (in degrees) between walls of alveolus measured in medium plane about 10-15 mm from protoconch; FA – fissure angle, being angle (in degrees) between wall of alveolus and straight line connecting intersection points of bottom of ventral fissure on wall of alveolus and outer margin of guard.

matological factors that are not fully understood to date. The study of modern squid may lead to new insights in these issues.

To round off, except for rostra, which occasionally preserve the very thin adapical portions of the rostrum cavum or in which the alveolus has been filled with indurated chalk or flint, no other parts of these squid are known in the study area, not even isolated arm hooks (see Riegraf, 1996; Janssen, 2012, for examples), although such are known from elsewhere, albeit in limited numbers.

Abbreviations –

Ls	length from apex to protoconch (in mm) [= LAP of Christensen, 1995, and Christensen *et al*., 2004];
Bs	lateral diameter halfway between apex and protoconch (in mm);
Bp	lateral diameter at protoconch (in mm);
Bc	lateral diameter at rostrum cavum (in mm) [= LDP of Christensen, 1995, and Christensen *et al*., 2004];
Ds	dorsoventral diameter halfway between apex and protoconch (in mm);
Dp	dorsoventral diameter at protoconch (in mm);
Dc	dorsoventral diameter at rostrum cavum (in mm) [= DVDP of Christensen, 1995, and Christensen *et al*., 2004];
Qp	Bp/Dp;
BI	Birkelund Index (BI = Ls/Dp) [= 'Elongation' of Schulz, 1982];
AV	ventral aspect (AV = (Bs – Bc) x 100/Bp in %);
AL	lateral aspect (AL = (Ds – Dc) x 100/Dp in %);
AVs	ventral aspect of rostrum solidum (AVs = (Bs – Bp) x 100/Bp in %);
ALs	lateral aspect of rostrum solidum (ALs = (Ds – Dp) x 100/Dp in %);
SD	Schatsky Distance; distance (in mm) between anterior part of protoconch and posterior part of ventral fissure, measured along the length axis of the rostrum;
AA	alveolar angle; dorsoventral angle (in degrees) between alveolar wall, measured along the central axis at 10-15 mm distance from the protoconch [note: during rostrum growth, the alveolar angle changes, which may result in quite divergent measurements]; and
FA	fissure angle; angle (in degrees) between the alveolar wall and the straight line which the intersection points of the bottom of the ventral fissure and the alveolar wall with the outer rostrum surface.

Measurements of Ls and SD can be taken to a precision of 0.5 mm by a ruler, but Bs, Bp, Bc, Ds, Dp and Dc need to be taken by calipers (to 0.1 mm). For analyses of belemnitellid 'populations', statistical methods need to be followed subsequently, determining arithmic mean, standard deviation (S), variation coefficient (CV) and observed range (OR). The relative growth of rostra can be captured in a linear regression analysis ($Dp = a + b \times Ls$).

Christensen (1995) and Christensen *et al*. (2004) introduced the following categories for the genus *Belemnitella*, in order to describe size, relative length and external shape of rostra, as well as SD and FA.

Birkelund Index
- BI < 4: stout
- BI between 4 and 5: slender
- BI > 5: very slender

Form
- AV and AL > 30 %: lanceolate
- AV and AL between 10 and 30 %: weakly lanceolate
- AV and AL between -10 and 10 %: subcylindrical
- AV and AL between -30 and -10 %: subconical
- AV and AL < -30 %: conical

Schatsky Distance
- < 4 mm: very small
- between 4 and 7 mm: small
- between 7 and 11 mm: large
- > 11 mm: very large

Fissure angle (FA)
- < 25 degrees: small
- between 25 and 45 degrees: medium
- between 45 and 65 degrees: large
- > 65 degrees: very large.

All specimens illustrated herein are deposited in the following collections: Natuurhistorisch Museum Maastricht (NHMM), with subsets indicated as follows: BL, L. Blezer Collection; MK, W. M. Felder Collection; JJ, J.W.M. Jagt Collection.

Systematic palaeontology

Class Coleoidea Bather, 1888
Order Belemnitida von Zittel, 1895
Suborder Belemnopseina Jeletzky, 1965
Family Belemnitellidae Pavlow, 1914
Genus *Belemnella* Nowak, 1913
Subgenus *Belemnella* Nowak, 1913
Subgenus *Pachybelemnella* Schulz, 1979
Subgenus *Neobelemnella* Naidin, 1975

Remarks – In all three subgenera, the rostrum cavum is completely calcified, that is, they have a genuine alveolus. In the study area, at least five species can be ascribed to these subgenera. All have irregularly formed, often wavy, dorsolateral double furrows, and the angle between the main vascular imprints and those double furrows is in excess of 30°, while the AA is between 10 and 23°, and the SD between 0 and 4.5 (5) mm. *Pachybelemnella* (type species: *Belemnella obtusa* Schulz, 1979, by original designation) is comprised of species with a relatively shorter rostrum solidum than those referred to the subgenus *Belemnella* (type species: *Belemnites lanceolatus* von Schlotheim, 1813 [ICZN Opinion 1328 [1985], name no. 2979]), which is moderately slender in species with a clavate profile and stout in those with weakly clavate to weakly conical rostra. The subgenus *Neobelemnella* (type species: *Belemnitella kazimiroviensis* Skołozdrówna, 1932, by monotypy), which externally is often difficult to distinguish from *Belemnitella junior*, is characterised by large values for AA (20-23°) and SD (3-5 mm), well-developed vascular imprints which branch from the dorsolateral double furrows under an angle of < 40°, and a short, conical juvenile stage.

***Belemnella* (*?Belemnella*) cf. *praearkhangelskii* Naidin, 1964**

Pl. 3, figs. 1, 2.

Description – Species characterised by a long, slender rostrum (Ls 67.3-74.3 mm), (weakly) lanceolate in ventral and cylindrical to weakly lanceolate in lateral aspect; faintly developed vascular imprints; acute apical end, well-developed mucro; small values for SD (0.5-2.5 mm) and AA (12-16°).

Occurrence – Known exclusively from the Vijlen Member (interval 4) at Altembroeck (‘s-Gravenvoeren, northeast Belgium; Keutgen, 1997, 2011), of middle *sumensis* Zone age (late early Maastrichtian).

***Belemnella* (*Pachybelemnella*) cf. *inflata* (Arkhangelsky, 1912)**

Pl. 1, figs. 1-3.

Description – Species characterised by a moderately long rostrum (Ls 60-72 mm), markedly clavate in ventral and weakly lanceolate in lateral aspect; obtuse apical end; vascular markings relatively weakly developed, but dorsolateral depressions and double furrows marked; small values for SD (1.0-2.5 mm) and AA (12-14°).

Occurrence – Confined to the basal Vijlen Member at Pesaken-Crapoel (southern Limburg) as remanié elements from the *Belemnitella minor* II Zone, of late late Campanian age (Keutgen *et al*., 2010; Keutgen, 2011).

Belemnella* (*Pachybelemnella*) ex gr. *sumensis*/*cimbrica

Pl. 3, figs. 5, 6.

Description – Representatives of the *sumensis*/*cimbrica* group have a stout, relatively short rostrum solidum (Ls 45-65 mm), generally with rounded apical end and comparatively weakly developed mucro; cylindrical to weakly clavate in ventral, conical to cylindrical in lateral aspect; vascular markings and dorsolateral double furrows mostly weakly developed; larger values for AA (14-17°) and SD (1.5-4 mm).

Discussion – In the middle portion of the Vijlen Member, belemnitellids occur which match the species concept of both *Belemnella* (*P*.) *sumensis* Jeletzky, 1949, and *Belemnella* (*P*.) *cimbrica* Birkelund, 1957, but most samples recorded previously in the literature are now considered reworked. From interval 3 of this member at Aachen-Schurzelterstraße, Keutgen *et al*. (2010) recorded *Belemnella* ex gr. *sumensis*/*cimbrica* below the first appearance datum (FAD) of *Belemnitella junior*; the mean values of this sample indicate either a late form of *Belemnella sumensis* or, alternatively, *Belemnella cimbrica*, a more precise identification being impossible. Early forms of *Belemnella sumensis* are common at

Altembroeck in interval 4 of the Vijlen Member (Keutgen, 1997, 2011), where they co-occur with *Belemnella* cf. *praearkhangelskii* (see above) and the typically late Maastrichtian *Belemnitella junior* and *Belemnitella lwowensis*. In northern Germany, *Belemnella praearkhangelskii* is of middle *sumensis* Zone age.

Occurrence – Common, but often reworked, in the middle portion of the Vijlen Member (intervals 3 and 4), in the border area between southern Limburg (the Netherlands) and the Voerstreek (Belgium), as well as near Vaals (Schneeberg), Lemiers, and between Vijlen and Aachen.

***Belemnella* (*Pachybelemnella*) *obtusa* Schulz, 1979**

Pl. 3, figs. 3, 4.

Description – Species characterised by a stout rostrum solidum (Ls 40-60 mm); in large-sized specimens, apical end obtuse; cylindrical to weakly clavate in ventral, clavate to cylindrical in lateral aspect; vascular markings and dorsolateral double furrows weakly developed; larger values for AA (14-17°) and SD (1.5-4 mm).

Occurrence – Fairly common, albeit exclusively reworked, in some 'belemnite graveyards' in the basal Vijlen Member, as at Slenaken and Beutenaken (Schulz, 1979; Keutgen & Van der Tuuk, 1991), of *obtusa* Zone age.

***Belemnella* (*Neobelemnella*) gr. *kazimiroviensis* (Skołozdrówna, 1932)**

Pl. 2, figs. 4-6.

Description – Characteristic of this group are relatively small to medium-sized, slender rostra (Ls 40-70 mm; mean 55 mm); acute apical end, barely developed mucro; lanceolate in ventral, lanceolate to subcylindrical in lateral aspect; vascular imprints, dorsolateral depressions and double furrows, and longitudinal striae well developed; bottom of ventral fissure curved downwards, generally S-shaped; large values for SD (3-4.5 mm) and AA (*c.* 20°).

Discussion – Van der Tuuk & Bor (1980, p. 128) noted that 'populations' of this species (or species group) appeared to comprise juvenile and subadult individuals only. This observation has been corroborated subsequently (J.W.M. Jagt, unpublished data). In fact, mature guards such as the one illustrated herein (Pl. 2, figs. 2, 3) are very rare. Birkelund (1957) was first to record this form from the Maastrichtian type area; to date, we know that representatives of this group (for which also the names *archangelskyi* Naidin, 1952, and *skolozdrownae* Kongiel, 1962, are available) are confined to the highest part of the Meerssen Member (Maastricht Formation), and possibly even indigenous at the base of the early Paleocene Geulhem Member in the Geulhem area, although most specimens from that level are abraded, fragmentary or have episkeletozoans. Others, however, appear to be (par)authochtonous.

Occurrence – Restricted to the upper Meerssen Member, the first representatives having been recorded from the top of subunit IVf-3/base of IVf-4 (J.W.M. Jagt, unpublished data). To date, I have seen material from the St. Pietersberg (ENCI HeidelbergCement Group quarry), the Geulhem-Berg en Terblijt area (former Ankerpoort-Curfs and Blom quarries; Geulhemmerberg subterranean galleries), and the Albert Canal between Vroenhoven and Veldwezelt (Belgium).

Genus *Belemnitella* d'Orbigny, 1840

Belemnitella junior Nowak, 1913

Pl. 2, figs. 1-3.

Description – Species characterised by large, but relatively slender rostra (Ls 51.8 mean, Dp 11.9 mm mean); generally subcylindrical in ventral and subconical in lateral aspect; slightly flattened over entire length; apical end obtuse or acute with well-developed mucro; dorsolateral depressions, double furrows and vascular imprints usually well developed; 'pseudogranulation' ventrally and longitudinal striae dorsally; mean values of Qp, BI, SD, FA and AA are 0.94, 4.3, 6.9 mm, 29.7° and 18.7°, respectively.

Discussion – As noted by Keutgen *et al*. (2010), this is a typical representative of the *Belemnitella mucronata* group, which co-occurs through most of its range with *Belemnitella lwowensis* of the *Belemnitella langei* group (see below).

Occurrence – Ranging from interval 4 of the Vijlen Member to the very top of the Maastricht Formation (Meerssen Member, subunit IVf-6) throughout the study area. Common in the Lanaye Member (Gulpen Formation), the basal Valkenburg Member, and at some intervals within the Emael and Nekum members (Maastricht Formation).

Belemnitella lwowensis Naidin, 1952

Pl. 1, figs. 4-6.

Description – Species characterised by fairly large and very slender rostra (Ls 49.2 mm mean; Dp 9 mm mean), weakly lanceolate to subcylindrical in ventral and subcylindrical in lateral view; flattened over entire length; apical end acute or slightly obtuse with well-defined mucro; dorsolateral depressions, double furrows and vascular markings usually well developed; 'pseudogranulation' ventrally, and longitudinal striae both ventrally and dorsally. Mean values for Qp, BI, SD, FA and AA are 0.91, 5.5, 6.3 mm, 55.6° and 18.7°, respectively.

Occurrence – Co-occurring with *Belemnitella junior* throughout its entire range, from the Vijlen Member (interval 4) up to the Emael Member (Maastricht Formation); in the Maastricht Formation, the ratio *lwowensis*/*junior* being around one to ten (Christensen *et al*., 2004; Keutgen *et al*., 2010).

Belemnitella cf. *minor* II Christensen, 1995

Pl. 1, figs. 7, 8.

Description – Species characterised by large-sized rostra (Ls 46.4 mean, DP 12.9 mm mean), stout, yet slightly more slender than typical *B. minor* II (mean BI *c*. 3.7); cylindrical or slightly conical in ventral and high conical in lateral aspect; juvenile guards more conical in both ventral and lateral views; slightly flattened over entire length; apical end acute or obtuse with mucro; vascular imprints well developed both laterally and ventrally, dorsolateral depressions and double furrows prominent; some specimens have 'pseudogranulation' ventrally and longitudinal striae on posterior dorsal side; mean values of Qp, SD, FA and AA of a 'population' from the basal Vijlen Member (Keutgen *et al*., 2010) are 0.98, 11.7 mm, 23.4° and 19.3°, respectively.

Discussion – This is stouter and with a larger SD than *Belemnitella minor* I, yet slightly more slender than the real *Belemnitella minor* II from the Paramoudra and Sidestrand Chalk members in Norwich, England (Christensen, 1995), with a mean BI value of 3.7.

Occurrence – Confined to the basal Vijlen Member at Pesaken-Crapoel (reworked; see *Belemnella* cf. *inflata* above), the Bovenste Bos quarry and the Beutenaken area (southern Limburg), ranging from late late Campanian to earliest Maastrichtian (see Keutgen *et al*., 2010; Keutgen, 2011).

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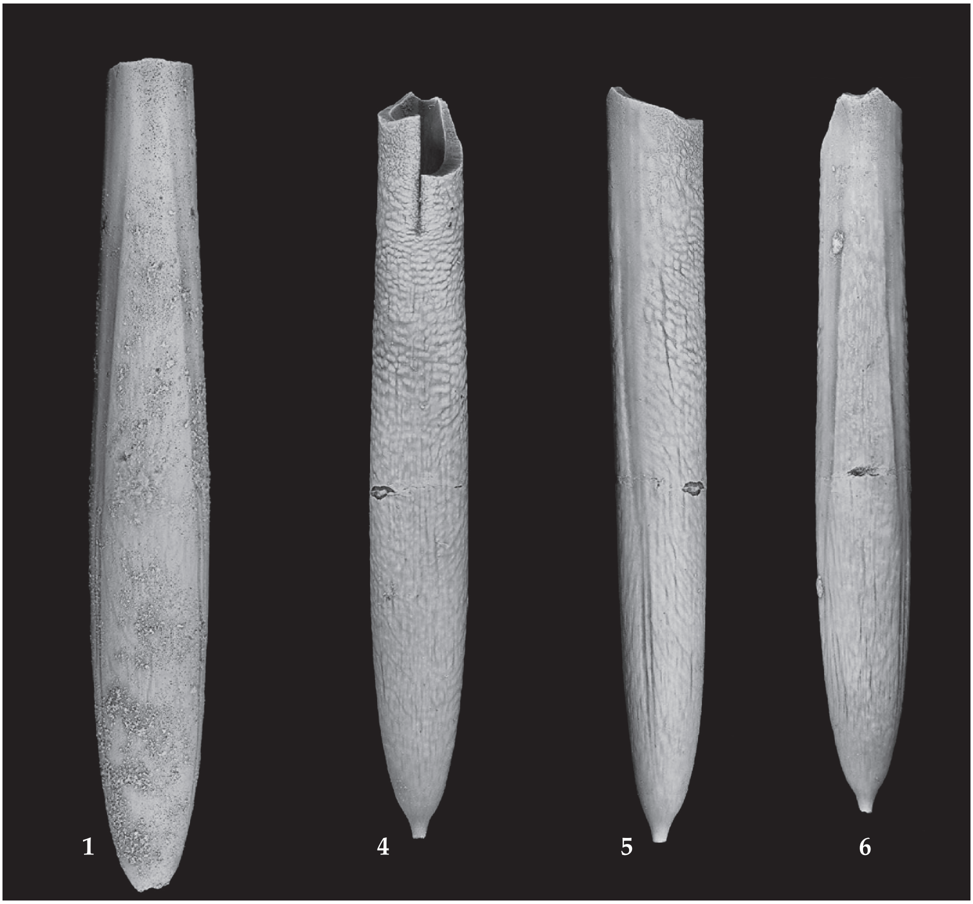

Plate 1

Belemnitellid coleoids from the extended type area of the Maastrichtian Stage (southeast Netherlands, northeast Belgium).

Figs. 1-3. *Belemnella* (*Pachybelemnella*) cf. *inflata* (Arkhangelsky, 1912); NHMM 2007 005/1; dorsal, lateral and ventral views, respectively; Gulpen Formation, basal Vijlen Member (reworked), Pesaken-Crapoel (southern Limburg, the Netherlands). L = 76 mm.

Figs. 4-6. *Belemnitella lwowensis* Naidin, 1952; NHMM 2007 026; ventral, lateral and dorsal views, respectively; Gulpen Formation, Vijlen Member (interval 6), former CPL SA-Haccourt quarry, Haccourt (Liège, northeast Belgium). L = 73 mm.

Figs. 7, 8. *Belemnitella* cf. *minor* II Christensen, 1995; NHMM 2007 002/1; lateral and ventral views, respectively; Gulpen Formation, basal Vijlen Member (reworked), Pesaken-Crapoel (southern Limburg, the Netherlands). L = 95 mm.

Specimens were coated with ammonium chloride prior to photography.

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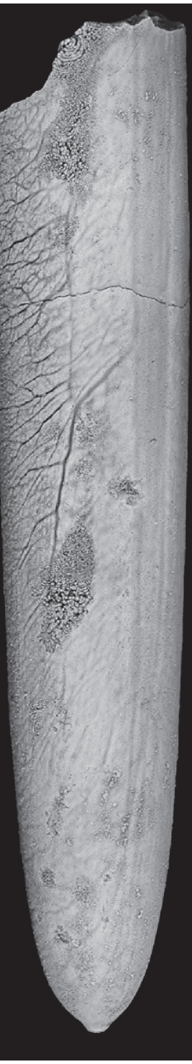

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Plate 2

Belemnitellid coleoids from the extended type area of the Maastrichtian Stage (southeast Netherlands, northeast Belgium).

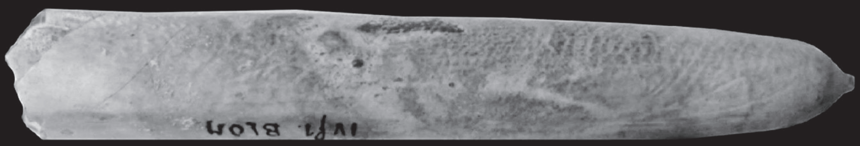
Figs. 1, 2. *Belemnitella junior* Nowak, 1913; NHMM BL 0414; lateral and ventral views, respectively; Maastricht Formation, basal Meerssen Member, former Blom quarry, Berg en Terblijt (southern Limburg, the Netherlands). L = 105 mm.

Fig. 3. *Belemnitella junior* Nowak, 1913; NHMM JJ 8451; lateral view of longitudinally split rostrum cavum to reveal internal features; Maastricht Formation, upper Nekum Member, ENCI-Heidelberg Cement Group quarry, Maastricht (southern Limburg, the Netherlands). L = 97 mm.

Fig. 4. *Belemnella* (*Neobelemnella*) gr. *kazimiroviensis* (Skołozdrówna, 1932); NHMM MK 3636; lateral view of longitudinally split rostrum cavum to reveal internal features; Maastricht Formation, top Meerssen Member; former Ankerpoort-Curfs quarry, Geulhem (southern Limburg, the Netherlands). L = 91 mm.

Figs. 5, 6. *Belemnella* (*Neobelemnella*) gr. *kazimiroviensis* (Skołozdrówna, 1932); NHMM JJ 2440; lateral (longitudinally split rostrum cavum to reveal internal features) and ventral views, respectively; Maastricht Formation, top Meerssen Member, Albert Canal, Vroenhoven-Riemst (Limburg, northeast Belgium). This particular specimen is close to '*Belemnitella*' *pensaensis* Naidin, 1952 from the uppermost Maastrichtian of the Penza area in central Russia, a form also known from correlative levels in Poland (see Kongiel, 1962, p. 32, pl. 1, figs. 4-12; pl. 2, figs. 1-6; pl. 3, figs. 1-3), in particular with regard to the course of the bottom of the ventral fissure. L = 108 mm.

All natural size.



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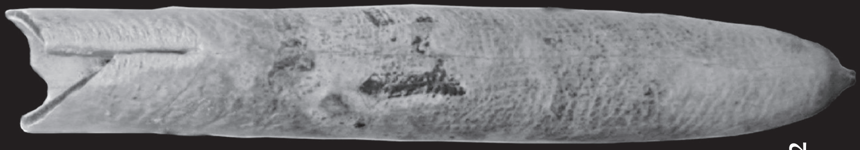

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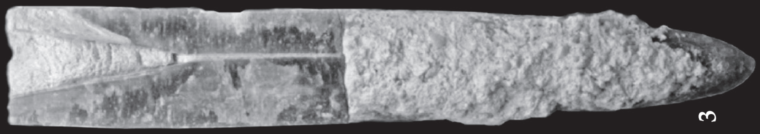

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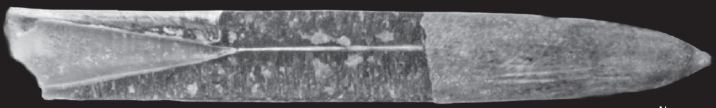

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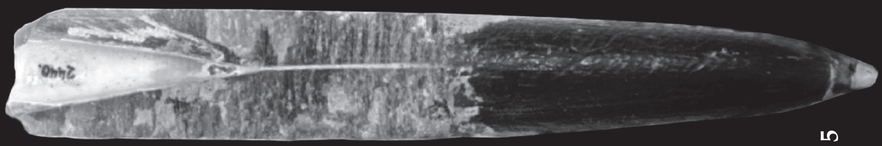

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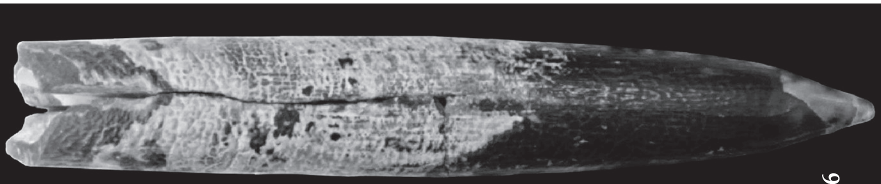

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Plate 3

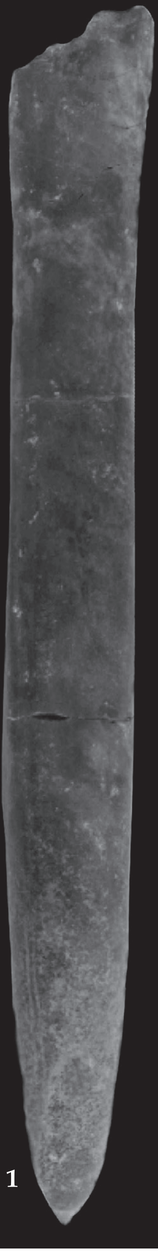
Belemnitellid coleoids from the extended type area of the Maastrichtian Stage (southeast Netherlands, northeast Belgium).

Figs. 1, 2. *Belemnella* (?*Belemnella*) cf. *praearkhangelskii* Naidin, 1964; NHMM 2010 128; lateral and ventral views, respectively; Gulpen Formation, Vijlen Member (interval 4), Altembroeck (‘s-Gravenvoeren, northeast Belgium).

Figs. 3, 4. *Belemnella* (*Pachybelemnella*) ex gr. *sumensis/cimbrica*; NHMM 2011 053 [*ex* Bm2-Su82]; lateral and ventral views, respectively; Gulpen Formation, Vijlen Member (interval 4), Altembroeck (‘s-Gravenvoeren, northeast Belgium).

Figs. 5, 6. *Belemnella* (*Pachybelemnella*) *obtusa* Schulz, 1979; NHMM 1997 074; ventral and lateral views, respectively; Gulpen Formation, lower Vijlen Member; Epen-Bovenste Bos (southern Limburg, the Netherlands).

All natural size.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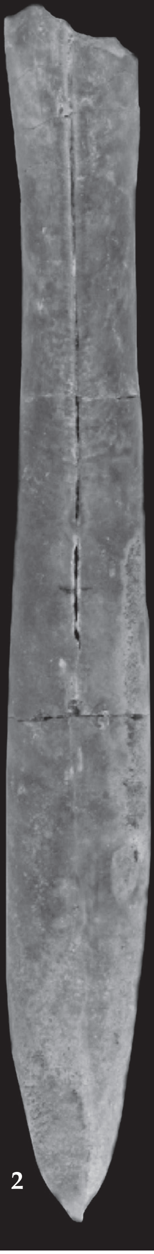
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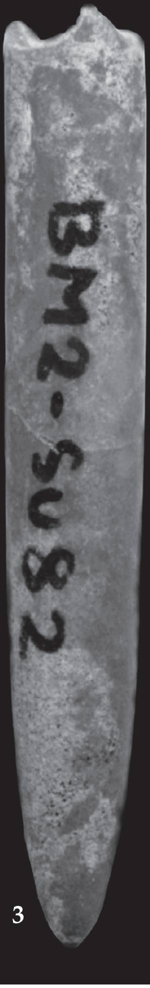
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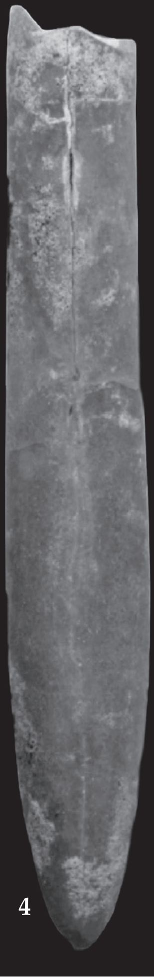
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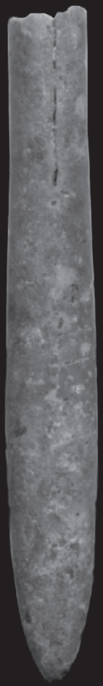
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