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Naturalis Biodiversity Center
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Latest Cretaceous *Pulvinites* (Bivalvia, Pterioidea, Pulvinitidae), new to the Maastrichtian type area, The Netherlands

JOHN W. M. JAGT

Natuurhistorisch Museum Maastricht, de Bosquetplein 6-7
NL-6211 KJ Maastricht, The Netherlands; john.jagt@maastricht.nl

On the basis of a single left valve, preserved as a calcitic-prismatic shell and an associated internal mould, a new species of pulvinitid, *Pulvinites elenae* spec. nov., is recorded from the uppermost Nekum Member (subunit IVe-7; Maastricht Formation, upper Maastrichtian) of the Sint-Pietersberg area, south of Maastricht. It differs from two European and North American congeners of comparable age, *P. adansonii* and *P. argenteus*, by being comparatively flat, with downturned lateral and ventral margins, as well as by being of smaller size and in having a rounded outline, and a short and low ligamental area with only 4-5 ligament pits.

Key words: Pteriomorphia, preservational states, taxonomy, Maastrichtian, The Netherlands.

INTRODUCTION

As a result of early diagenetic dissolution of aragonite, latest Cretaceous (67.8-66 Ma) bivalve faunas from the type area of the Maastrichtian Stage (Fig. 1) are severely biased towards calcitic pteriomorphs such as members of the (sub)families Mytilidae (Mytilinae, Lithophaginae), Pinnidae, Bakevelliidae, Inoceramidae, Oxytomidae, Amusiidae, Pectinidae, Spondyliidae, Dimyidae, Limidae, Gryphaeidae, Ostreidae, Monopleuridae, Hippuritidae and Radiolitidae (Van de Geijn, 1940; Dhondt, 1998, 1999; Jagt & Jagt-Yazykova, 2018). Other bivalves, mostly representatives of the families Nuculidae, Nuculanidae, Arcidae, Cucullaeidae, Limopsidae, Glycymerididae, Lucinidae (Lucininae, Fimbriinae), Astartidae, Crassatellidae, Pterotrioniidae, Carditidae, Cardiidae, Pharidae, Tellinidae, Veneridae, Corbulidae, Hiattellidae, Pholadomyidae, Laternulidae, Thraciidae (?) and

Poromyidae occur exclusively as external and internal moulds (Briart, 1888; Vogel, 1895; Abdel-Gawad, 1986; Dhondt et al., 1996; Jagt et al., 2014; Jagt, 2015). Only where early diagenetic silicification and replacement of aragonite by calcite or silica or encapsulation in flint occurred can details of shell and hinge be studied in detail (Dhondt & Jagt, 1989, 1997). On account of this skewed preservation, pteriomorphs have been studied in considerable detail (e.g., Dhondt, 1971, 1972a, b, 1973a, b, 1976, 1979, 1983, 1990, 1998, 1999), whereas other bivalve groups are markedly under-represented in the literature. However, attempts are currently being made to ameliorate this bias in the standard collection of Late Cretaceous macrofossils held by the Natuurhistorisch Museum Maastricht (abbreviation: NHMM).

The present left valve of a pulvinitid is a fortuitous find, in view of the fact that it comprises the calcitic-prismatic shell in association with the internal mould that reveals details of adductor and retractor scars and of the multivincular ligament. The specimen originates from the uppermost, indurated part of the Nekum Member (subunit IVe-7; sensu Felder & Bosch, 1998) (Fig. 2), in association with common turritellid gastropods (Binkhorst van den Binkhorst, 1861-1862; Kaunhowen, 1898), serpulid polychaetes (Jäger, 2005, 2012) and rare micrabaciid corals (Leloux, 1997, 1999).

SYSTEMATIC PART

The higher-level classification adopted here follows Tëmkin (2010) and the World Register of Marine Species/MolluscaBase (<http://www.molluscabase.org>).

Infraclass Pteriomorphia Beurlen, 1944

Superfamily Pterioidea Gray, 1847

Family Pulvinitidae Stephenson, 1941

Diagnosis. – Pterioidea with byssal foramen in right valve formed by fusion of shell along byssal notch early in ontogeny; posterior pedal retractor scar in right valve much smaller than and separated from adductor scar; posterior pedal retractor scar of left valve equal to or larger than adductor scar and well separated from it; ligament prosodetic, multivincular (modified from Ward & Waller, 1988: 53).

Pulvinites DeFrance, in de Blainville, 1824

Pulvinites DeFrance, in de Blainville, 1824: 316. Type species (by monotypy): *Pulvinites adansonii* DeFrance, in de Blainville, 1824 (= *Hypotrema* d'Orbigny, 1853: 435).

Remarks. – Cox (1969: N326) indicated the stratigraphical range of the genus to be Late Jurassic to Recent; subsequently, records of Early and Middle Jurassic age have been added (see Table 1).

Pulvinites(?) spec.

Early Jurassic (Hettangian); Vendée, France (Cossmann, 1904; Pacaud, 2001)

Pulvinites liasicus Damborenea, 1987

Early Jurassic; Argentina (Damborenea, 1987)

Pulvinites mackerrowi Palmer, 1984

Middle Jurassic (Bathonian); Oxfordshire, England (Palmer, 1984; Pacaud, 2001)

Pulvinites(?) *abadiensis* Fürsich & Werner, 1989

Late Jurassic (Kimmeridgian); Portugal (Fürsich & Werner, 1989)

Pulvinites rupellensis d'Orbigny, 1850

Late Jurassic (Kimmeridgian); Charente-Maritime, France (d'Orbigny, 1850; Pacaud, 2001)

Pulvinites(?) spec.

Late Jurassic (early Tithonian); Bavaria, southern Germany (Yamani, 1975)

Pulvinites adansonii de Blainville, 1824 (? = *Pulvinites auriculus*

Vokes, 1941)

Late Cretaceous (Cenomanian, Campanian and late Maastrichtian); Cotentin, France (de Blainville, 1824; Pacaud, 2001)

Pulvinites antarctica Zinsmeister, 1978 (? = *Pulvinites adansonii*

DeFrance, in de Blainville, 1824)

Late Cretaceous (Campanian and early Maastrichtian); Antarctica (Zinsmeister, 1978)

Pulvinites elenae spec. nov.

Late Cretaceous (late Maastrichtian); southern Limburg, the Netherlands (present paper)

Pulvinites argenteus Conrad, 1858

Late Cretaceous (Maastrichtian and early Paleogene [Danian]); Mississippi, Tennessee, Texas, Alabama, USA; Egypt (Conrad, 1858; Wade, 1926; Pacaud, 2001)

Pulvinites dysporista Pacaud, 2001

Early Paleogene (Danian); Val d'Oise, France (Pacaud, 2001)

Pulvinites californica Zinsmeister, 1978

Late Paleocene (Thanetian); California, USA (Zinsmeister, 1978)

Pulvinites pacifica Zinsmeister, 1978

Late Paleocene (Thanetian); California, USA (Zinsmeister, 1978)

Pulvinites lawrencei Ward & Waller, 1988

Late Paleocene (Thanetian); Virginia, USA (Ward & Waller, 1988)

Pulvinites exempla (Hedley, 1914)

Recent; New South Wales, Tasmania and Victoria, Australia; New Zealand and Kermadec Island (Hedley, 1914; Marshall, 1998; Pacaud, 2001; Tëmkin, 2006)

Table 1. Extinct and extant species of *Pulvinites* (= *Hypotrema*) known to date, arranged chronostratigraphically (www.stratigraphy.org) and with pertinent literature sources.

Pulvinites elenae spec. nov. (Fig. 3)

Diagnosis. – Rather small-sized (L = 20.5 mm), orbicular and comparatively flat left valve, with downturned lateral and ventral margins; length exceeding height (L/H ratio 1.11); shell margins well rounded; dorsal margin slightly prolonged posteriorly; length of ligament (c. 4.7 mm) slightly less than one third of length of dorsal margin; interior with posterior pedal retractor scar smaller than adductor scar; anterior pedal retractor scar barely visible, presumably elongated triangular in outline; two smaller pits possibly representing subsidiary muscle scars; ligamental area short and low, with 4 or 5 narrow, elongate and subparallel ligamental pits; internal shell surface demonstrating externally lamellose and oyster-like habitus.

Material. – The holotype (NHMM JJ 14601a-b) is a single left valve preserved as calcitic-prismatic outer shell (visible from the inside, Fig. 3F) and an associated natural internal mould which shows details of retractor and adductor scars and ligamental area (Fig. 3A-E).

Locality and stratigraphy. – NHMM JJ 14601a-b was collected (April 2011) from the indurated upper 0.5 metres of subunit IVe-7 of the Nekum Member (Maastricht Formation) of late Maastrichtian age (zone with the belemnite-like coleoids *Belemnitella junior* Nowak, 1913 and *B. lwowensis* Naidin, 1952) in the southwestern corner of the ENCI-HeidelbergCement Group quarry, Maastricht (see Jagt, 2012; Jagt & Jagt-Yazykova, 2012).

Derivatio nominis. – After my wife, Elena Aleksandrova Yazykova (née Zonova), who is just as unique and appealing as the new bivalve described herein.

Description. – Comparatively small-sized, orbicular and comparatively flat left valve; shell length exceeding height (L/H ratio 1.11); umbo opisthogyrate; dorsal margin posterior to umbo nearly straight for almost twice the length of the ligamental area; dorsal margin anterior of umbo broadly rounded; ventral and lateral margins broadly rounded. Ligamental area short and low, slightly less than one third of length of dorsal shell

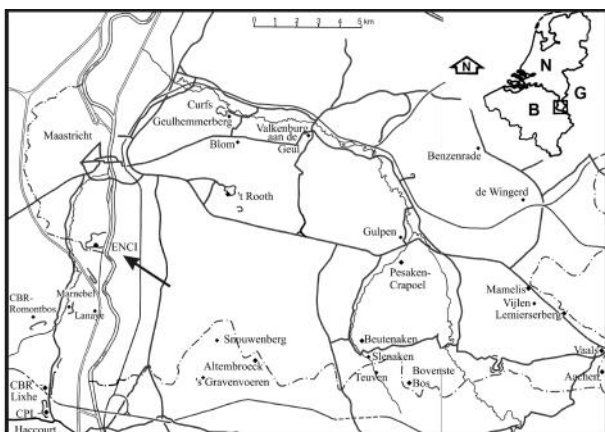


Fig. 1. Map of the extended type area of the Maastrichtian Stage (southern Limburg [the Netherlands] and contiguous Belgian and German territories), with key localities indicated. The ENCI-HeidelbergCement Group quarry, south of Maastricht, is arrowed.

margin, with 4-5 subparallel ligament pits, each elongated triangular in outline, with a pointed proximal and a rounded distal end; spacing unequal. Posterior pedal retractor scar longer than wide, smaller than ventrally rounded adductor scar; anterior pedal retractor scar barely visible, but (under low-angle light) apparently elongated triangular in outline; two smaller pits posteriorly possibly represent subsidiary muscle scars; internal shell surface clearly demonstrating externally lamellose (i.e., numerous irregular commarginal undulations), oyster-like habitus.

Measurements. – Greatest length 20.5 mm; greatest height 18.5 mm; concavity c. 3.5 mm; length of ligamental area c. 4.7 mm; estimated length of adductor scar: c. 7 mm; estimated length of posterior pedal retractor scar: c. 5 mm; estimated length of anterior pedal retractor scar: >3.5 mm.

Discussion. – Preserved are only a single calcitic-prismatic outer shell of a left valve and the associated natural internal mould of medium-grained biocalcarenite. In life, both valves had a thick nacreous inner layer that was lost during diagenesis. That the present specimen retains individual prisms of the outer calcitic shell can be linked to its embedment, soon after disarticulation, in a level that subsequently became indurated as a result of rapid post-depositional consolidation of the sea floor. Naturally, details of imprints of the adductor and retractor scars and of the ligamental area rely heavily on the grain size of the matrix (Fig. 3E). In this particular case, the matrix is a medium-grained limestone which accounts for the fact that some of the measurements are approximate at best. However, both shell and internal mould are preserved three-dimensionally in this indurated level which protected them from sediment compaction.

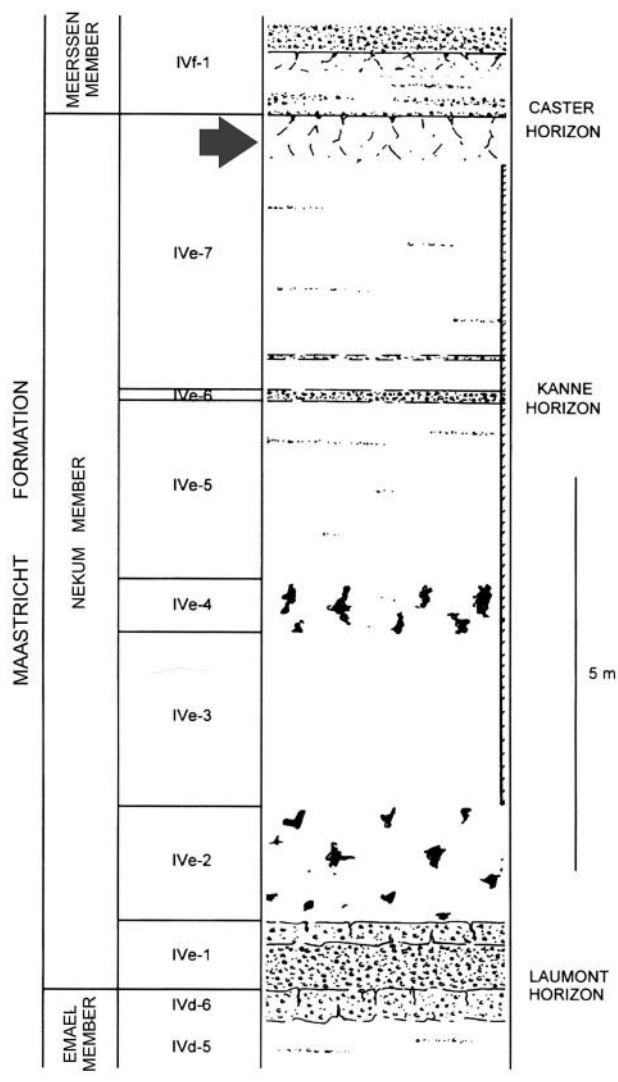


Fig. 2. Log of the Nekum Member (Maastricht Formation) as exposed at the ENCI-HeidelbergCement Group quarry, with indication (arrow) of the level that yielded the holotype, and sole known specimen, of *Pulvinites elenae* spec. nov. (modified after Felder & Bosch, 1998: fig. 16).

To date, only two congeneric species of coeval (i.e., latest Cretaceous, late Maastrichtian) age have been recorded. *Pulvinites adansonii*, from the upper Maastrichtian 'Calcaire à *Baculites*' of Manche (Cotentin, northwest France; see Kennedy, 1986; Walaszczyk & Kennedy, 2011), is either orbicular or trigonal in shell outline, with a straight, slightly convex or slightly concave postero-dorsal margin. Adult left valves are weakly inflated with a length of around 53 mm, with shell length usually slightly exceeding shell height and c. 7-11 ligament pits on the ligamental area measuring between c. 6 and 11 mm. The ratio of valve length to length of ligamental area is greater than 4. In the left valve, the scars of the adductor and posterior pedal retractor muscles do not touch; moreover, a division of the adductor scar into quick-and-catch portions is occa-

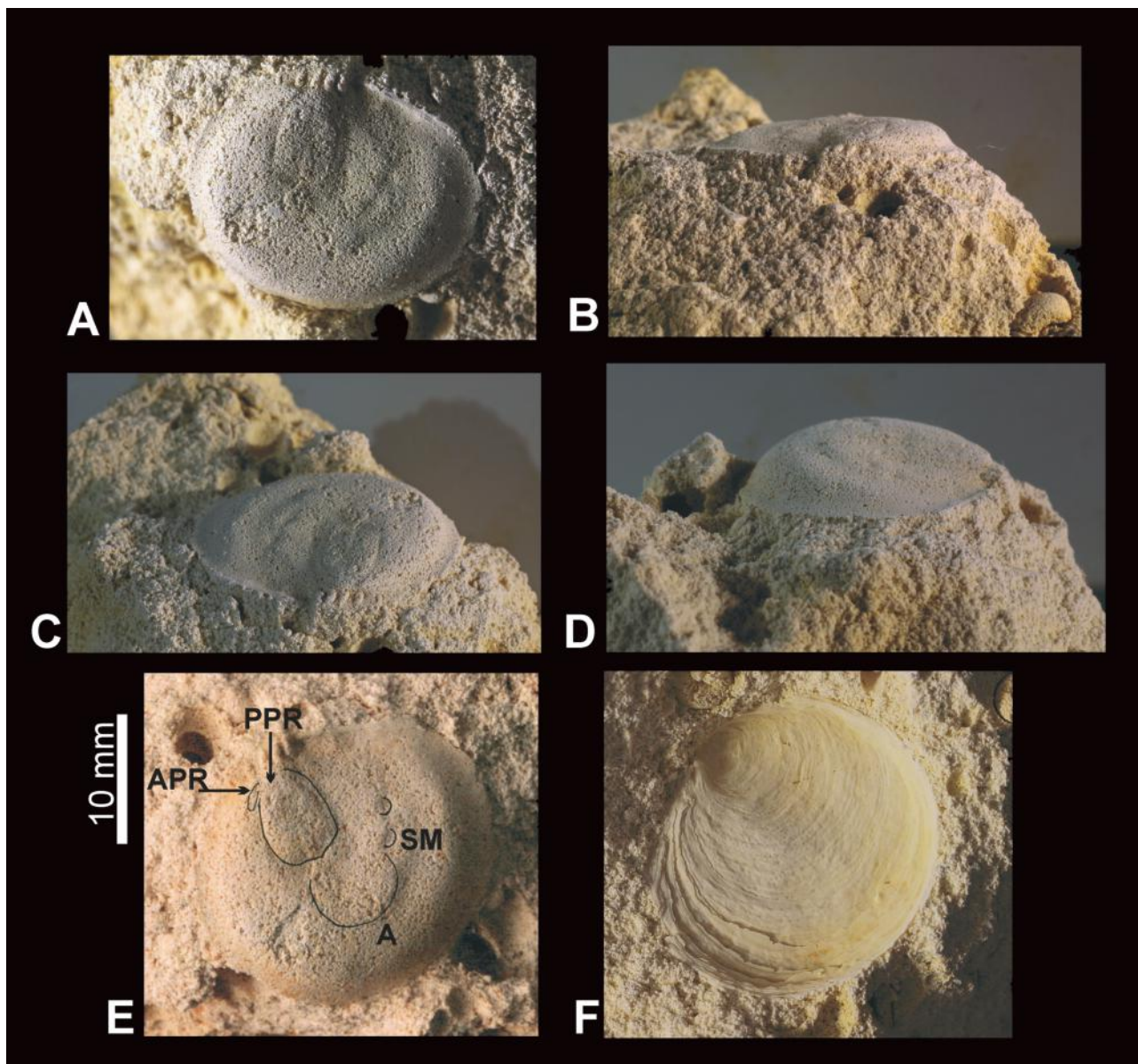


Fig. 3. *Pulvinites elenae* spec. nov., holotype (NHMM JJ 14601a-b), ENCI-HeidelbergCement Group quarry (Maastricht), Nekum Member, top of subunit IVe-7 (Maastricht Formation, upper Maastrichtian; see Fig. 2). **A-D**, Internal mould of left valve, in various aspects (coated with ammonium chloride prior to photography); **E**, Interpretative drawing of adductor and retractor scars (see A, C-D). **F**, Inner surface of outer shell of left valve. Abbreviations: **APR**, anterior pedal retractor scar; **PPR**, posterior pedal retractor scar; **A**, adductor scar; **SM**, subsidiary muscle scars. Photographs by Allart van Viersen and Mart Deckers.

sionally seen (see Palmer, 1984: 819). This species differs from *Pulvinites elenae* spec. nov. in being of larger size and weakly inflated (vs comparatively flat and faintly concave) and a greater number of ligament pits, although this is growth related.

The shell of *Pulvinites argenteus*, from the upper Maastrichtian Ripley Formation of Mississippi and Tennessee and correlative levels in Texas and Alabama (all USA), is orbicular, or trigonal in outline and has a straight, convex or slightly concave postero-dorsal margin. Adult left valves are weakly or moderately inflated, measuring c. 53 mm; the length is equal to, slightly

greater or slightly less than the height; there are 10-15 ligament pits on a ligamental area of c. 9-15 mm in length; the ratio of valve length to length of ligamental area is less than 4. Scars of the adductor and posterior pedal retractor muscles do not touch in the left valve (Palmer, 1984: 820). In comparison with the new species, *P. argenteus* is of larger size, less clearly orbicular in outline, has an inflated left valve and lacks a near-straight dorsal margin posteriorly of the umbo; in addition, it has a longer and taller ligamental area with a greater number of ligament pits.

None of the remaining species (Table 1), of Jurassic,

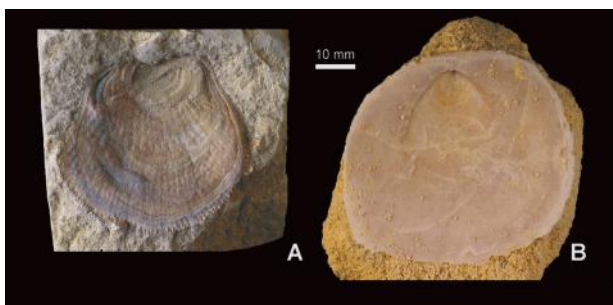


Fig. 4. Other superficially similar Late Cretaceous bivalves from the study area. **A**, *Placunopsis granulosa* (Roemer, 1841) (NHMM JJ 8639), CBR Lixhe quarry, Lixhe (Liège, northeast Belgium), Vijlen Member interval 6, base + 5-6 m (Gulpen Formation, upper Maastrichtian), inside of left valve; **B**, Indeterminate anomiid (NHMM JJ 10387), ENCI-HeidelbergCement Group quarry, Maastricht, Nekum Member, base + 3.5-4 m (Maastricht Formation, upper Maastrichtian), inside of left valve. Photographs by Wilfried Miseur.

Cretaceous and Cenozoic age, have a similarly orbicular, comparatively small-sized and flat to faintly concave left valve with a small and low ligamental area and only 4-5 ligament pits. In conclusion, the introduction of a new species to accommodate a latest Maastrichtian representative from the stratotypical Maastrichtian appears warranted, despite the fact that only a single left valve is now available for study.

Lastly, there is also a certain superficial resemblance to two other Late Cretaceous (Campanian-Maastrichtian) bivalve taxa, both of which are known from the study area. The first is the terquemiid *Placunopsis granulosa* (Roemer, 1841) (Fig. 4A) (compare Abdel-Gawad, 1986: 158, pl. 36 figs 4-7), which is cemented to a biogenic or abiogenic substrate by most of the right valve and thus has a highly variable outline. The flat to feebly convex left valve is regularly found lying loose in matrix, just like the present specimen. Shell ornament consists of numerous, close-set, granulated radial riblets that are crossed by irregular growth lines, making the shell margins appear serrated (see also Holzapfel, 1889). I know of finds of both right and left valves from the Vijlen and Lixhe 1 member (Gulpen Formation, upper Maastrichtian; see Fig. 5). Secondly, there are isolated left valves of anomiiids (Fig. 4B), generically and specifically indeterminate for the time being, that co-occur with *Pulvinites elenae* spec. nov. in the upper part of the Maastricht Formation. These lack the ligamental area with pits and the shell interior is smooth, the shell itself lamellar and shiny where broken. The right valve, with the opening for the byssal plug, is much rarer being prone to *post-mortem* destruction.

A survey of older literature sources (e.g., Bosquet, 1860, 1868; Vogel, 1895) shows that there is no previous

		Lutterade
	Geleen Member	Geleen
Houthem Formation	Bunde Member	Bunde
	Geulhem Member	Vroenhoven
	Meerssen Member	Caster
	Nekum Member	Laumont
Maastricht Formation	Emael Member	Romontbos
	Schiepersberg Member	Schiepersberg
	Gronsveld Member	St. Pieter
	Valkenburg Member	Lichtenberg
	Lanaye Member	Nivelle
	Lixhe 1-3 Members	Wahlwiller
Gulpen Formation	Vijlen Member	Bovenste Bosch
	Beutenaken Member	Slenaken
	Zeven Wegen Member	Zeven Wegen
	Benzenrade Member	Benzenrade
	Terstraten Member	Terstraten
Vaals Formation	Beusdal Member	Beusdal
	Vaalsbroek Member	Overgeul
	Gemmenich Member	Gemmenich
	Cottessen Member	Cottessen
	Raren Member	Raren
	Hauset Member	Flög
Aken Formation	Aken Member	Schampelheide
	Hergenrath Member	Hergenrath

Fig. 5. Lithostratigraphical subdivision (formations, members and horizons) of Upper Cretaceous (Santonian-Maastrichtian) strata in southern Limburg and contiguous areas.

record of pulvinitid bivalves from the type Maastrichtian; they must be considered extremely rare. In addition to the holotype, I am aware (pers. obs.) of the find of at least one additional left valve (albeit without associated internal mould) from the same locality and stratigraphical unit. However, its present whereabouts are unknown to me.

Occurrence. – To date, known exclusively from the type locality and stratigraphical level.

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