

New species of dinoflagellate cysts from the Campanian–Danian chalks at Hallembaye and Turnhout (Belgium) and at Beutenaken (the Netherlands)

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ABSTRACT – A palynological study of Campanian–Danian chalks from the quarries at Beutenaken and Hallembaye (Maastricht region) and from a borehole at Turnhout (northern Belgium) has revealed the presence of seven new species and subspecies of dinoflagellate cysts: *Exochosphaeridium? Masureae* sp. nov., *Leberidocysta chlamydata* subsp. *schioleii* subsp. nov., *Odontochitina streelii* sp. nov., *Pervosphaeridium septatum* sp. nov., *Spiniferites ramosus* subsp. *pteroceus* subsp. nov., *Stephodinium? spinosum* sp. nov. and *Xenascus wetzelii* sp. nov. *Nexospinum? complicatum* described by Slimani (1996) as a new species is now a junior synonym of *Pulchrasphaera minuscula* Schiøler *et al.* (1997). *J. Micropalaeontol.* 20(1): 1–11, July 2001.

INTRODUCTION

Upper Cretaceous sediments have been sampled in the quarries of Beutenaken and Hallembaye (Figs 1–3) and in the cored borehole at Turnhout (Fig. 4). In an earlier publication (Slimani, 1994) six new genera were defined, 55 new species described and

some new combinations and emendations proposed. In a later paper (Slimani, 1996) eight new taxa were described in French. However, according to the International Code of Botanical Nomenclature (1994 edition, Article 36.3) new taxa can only be validated if the diagnosis or description is given in Latin or

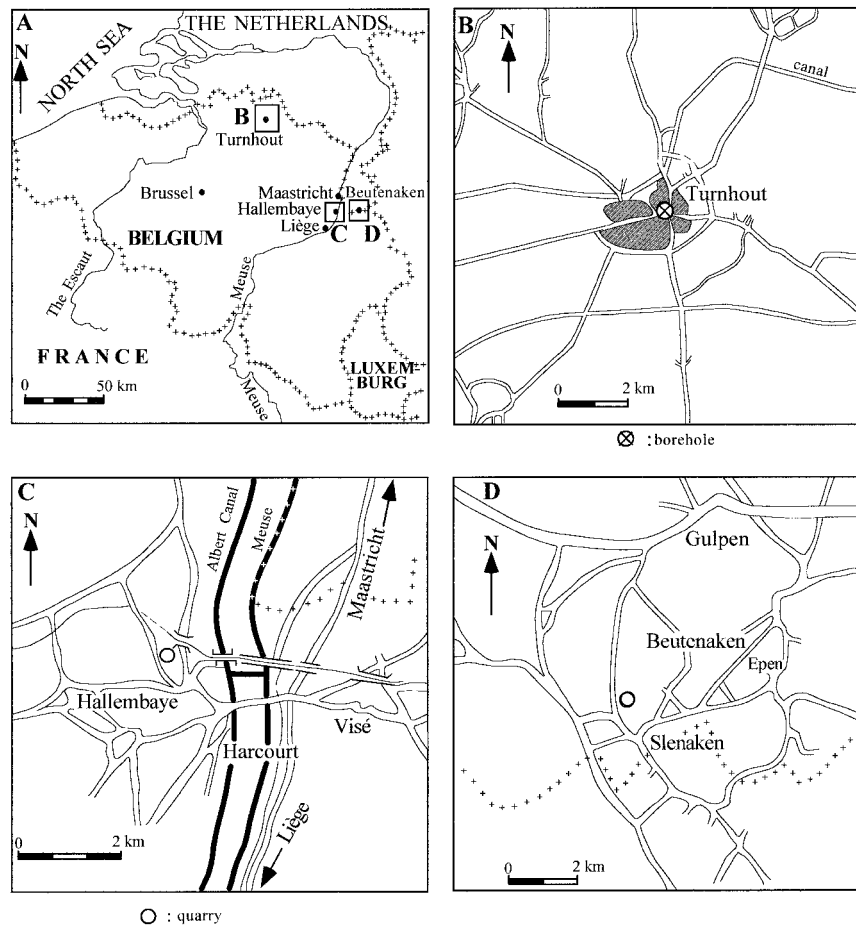


Fig. 1. Location of the Beutenaken and Hallembaye quarries and the Turnhout borehole (B, location of the Turnhout borehole; C, location of the Hallembaye quarry; D, location of the Beutenaken quarry).

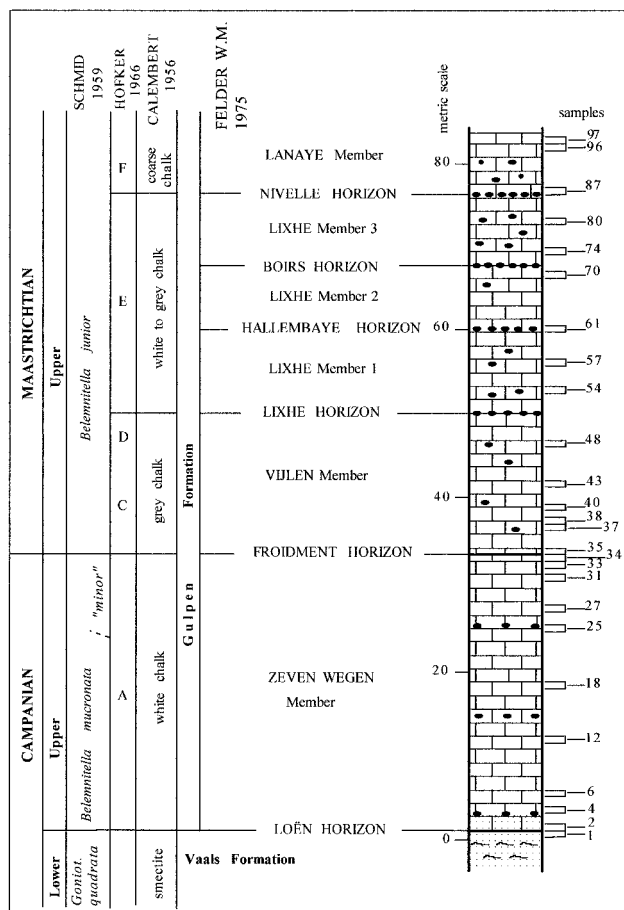


Fig. 2. Lithology, biostratigraphy and sampling of the Hallembaye quarry (*Goniat. quadrata*=*Goniatolithus quadrata*) (modified from Robaszynski *et al.*, 1985).

English. To meet this recommendation the present paper gives the diagnosis of the seven new taxa in English.

SYSTEMATIC PALYNOLOGY

Holotypes and paratypes of the new species are conserved in the Micropalaeontological collections of the Laboratory of Palaeontology, Department of Geology, University of Gent, Belgium, under the references given in the text.

Division **Pyrrophyta** Pascher, 1914

Class **Dinophyceae** Fritsch, 1929

Order **Peridinales** Haeckel., 1894

Genus *Exochosphaeridium* Davey, Downie, Sarjeant & Williams, 1966b

Exochosphaeridium? masureae sp. nov.

(Pl. 1, figs 1, 2, 4, 5; Pl. 2, fig. 10)

1983 '*Exochosphaeridium? acuminatum*' Wilson, 1974; Foucher: table of stratigraphic distribution.

1985 '*Exochosphaeridium? acuminatum*' Wilson; Foucher *in* Robaszynski *et al.*: figs 20, 21.

1985a '*Exochosphaeridium? acuminatum*' Wilson; Masure: fig. 1F.

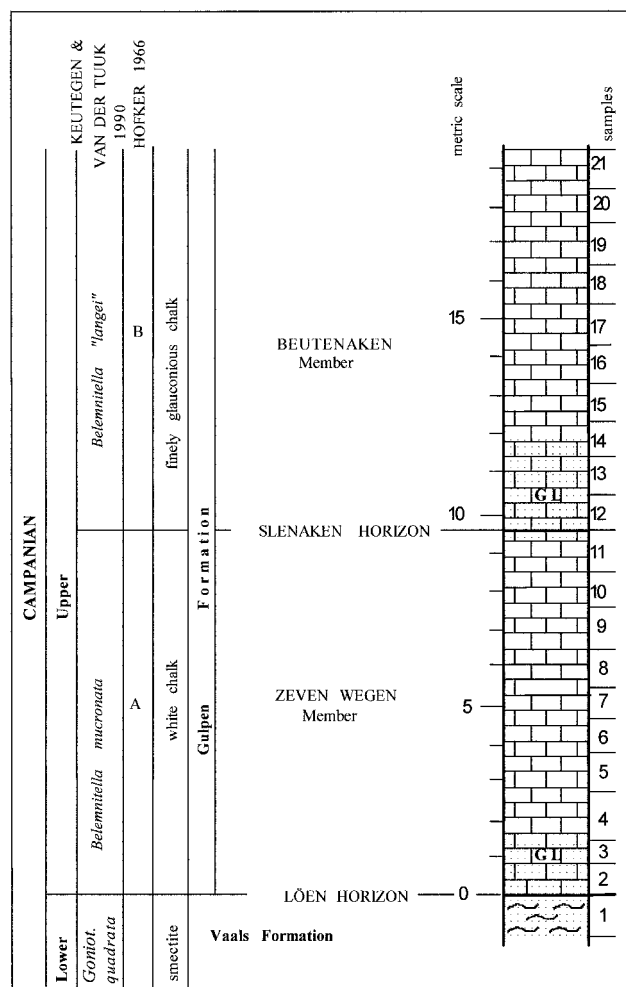


Fig. 3. Lithology, biostratigraphy and sampling of the Beutenaken quarry (*Goniat. quadrata*=*Goniatolithus quadrata*) (modified from Robaszynski *et al.*, 1985).

1989 '*Exochosphaeridium? acuminatum*' Wilson; Masure; Lentin & Williams: 133.

1993 '*Exochosphaeridium? acuminatum*' Wilson; Masure; Lentin & Williams: 217.

1996 *Exochosphaeridium? masurei* sp. nov. Slimani: 373–374, pl. 1, figs H–L.

1998 '*Exochosphaeridium? masureae*' Slimani, 1996; Williams, Lentin & Fensome: 222.

Type species. *Exochosphaeridium bifidum* (Clarke & Verdier, 1967) Clarke *et al.*, 1968 *subsp. bifidum*.

Derivation of name. In honour of Dr Edwige Masure, Laboratory of Micropalaeontology, Université Pierre et Marie Curie, Paris, France.

Diagnosis. Skolochorate cyst with ovoidal to spherical central body. Periphragm and endophragm smooth and appressed between processes. Numerous hollow and closed processes, wide proximally with a subcircular to oval cross-section, simple and acuminate distally or subdivided in smaller acuminate processes. Process often connected proximally and give a reticulate aspect

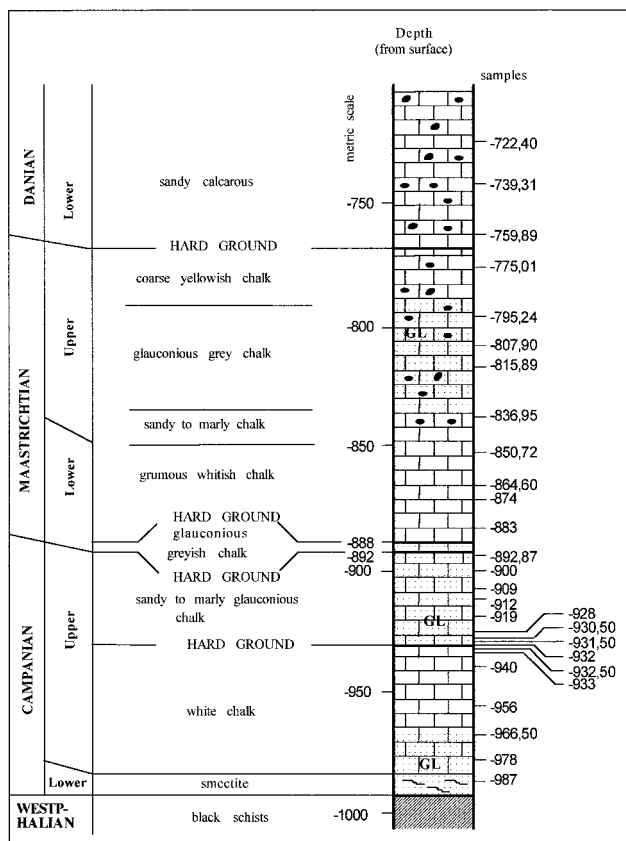


Fig. 4. Lithology and sampling of the Turnhout borehole (GL=glauconite).

of the cyst. Vague paratabulation partially indicated by more or less defined groups of precingular, paracingular, postcingular and sulcal processes. Levorotatory paracingulum, often somewhat more clearly indicated by an alignment of two rows of processes. Distinct apical process solid, larger than the other processes, and irregularly branched. Precingular archeopyle P(3'') with free operculum.

Holotype. Turnhout – 956 m, preparation 8, coord. E.F. V51/4 (Pl. 1, figs 1, 2).

Paratype. Hallembaye sample 18, preparation 3, coord. E.F. F32/3 (Pl. 2, fig. 10).

Type locality & horizon. Turnhout – 956 m. Campanian.

Dimensions. Holotype: diameter of central body – 65 µm, length of processes – 6–20 µm; paratype: diameter of central body – 50 µm, length of processes – 6–16 µm; other specimens: diameter of central body – 50–70 µm, length of processes – 6–14 µm. Specimens measured: 10.

Stratigraphical range. Beutenaken: sample 1–11 (Lower–Upper Campanian); Hallembaye: sample 12–27 (Upper Campanian); Turnhout: – 978 up to – 933 m (Upper Campanian).

Stratigraphical and geographical distribution. Belgium [in Louwey (1991): Campanian]; Belgium and the Netherlands [in Wilson (1974): Late Campanian (lower part of *B. mucronata* Zone, Maastricht region)]; France [Foucher (1983, 1985):

Campanian; Masure (1985a): Campanian; Autoroute A10, Masure (1985b): Campanian, Charente].

Remarks. The attribution of the species to the genus *Exochosphaeridium* is uncertain as the cyst wall in other *Exochosphaeridium* species is, in general, fibrous while it is smooth in *Exochosphaeridium? masureae*. The processes of *E? masureae* resemble those of *Florentinia ferox* (Deflandre, 1937) and *Raetiaedinium belgicum* Slimani (1994). However *Florentinia* and *Raetiaedinium* respectively present a combination archeopyle (apical paraplates+one precingular paraplate) and precingular (2P) archeopyle, while in *E? masureae* one encounters a precingular P(3'') archeopyle.

Genus *Leberidocysta* Stover & Evitt, 1978

Leberidocysta chlamydata (Cookson & Eisenack, 1962) Stover & Evitt, 1978 subsp. *schioleii* subsp. nov.

(Pl. 1, figs 10–13; Pl. 2, figs 5, 6, 9)

1971 *Hexagonifera chlamydata* Cookson & Eisenack, 1962; Wilson: pl. 4, fig. 8.

1986 *Leberidocysta chlamydata* (Cookson & Eisenack, 1962) Stover & Evitt, 1978; Marheinecke: pl. 1, fig. 4, pl. 17, fig. 4.

1991 *Leberidocysta chlamydata* (Cookson & Eisenack, 1962) Stover & Evitt, 1978; Kirsch: 124, pl. 4, figs 5, 8.

1992 *Leberidocysta chlamydata* (Cookson & Eisenack, 1962) Stover & Evitt, 1978; Marheinecke: 88–89, pl. 18, figs 4, 8, 10, 11.

1993 *Leberidocysta aff. chlamydata* (Cookson & Eisenack, 1962) Stover & Evitt, 1978; Schiøler & Wilson: 347, pl. 3, fig. 10.

1996 *Leberidocysta chlamydata* (Cookson & Eisenack, 1962) Stover & Evitt, 1978 subsp. *schioleii* sp. nov. Slimani: 375, pl. 1, figs A–G.

1998 *Leberidocysta chlamydata* (Cookson & Eisenack, 1962) Stover & Evitt, 1978 subsp. '*schioleii*' Slimani, 1996; Williams, Lentin & Fensome: 361.

Type species. *Leberidocysta chlamydata* (Cookson & Eisenack, 1962) Stover & Evitt, 1978.

Derivation of name. In honour of Dr Poul Schiøler, Geological Survey of Denmark, Copenhagen, Denmark.

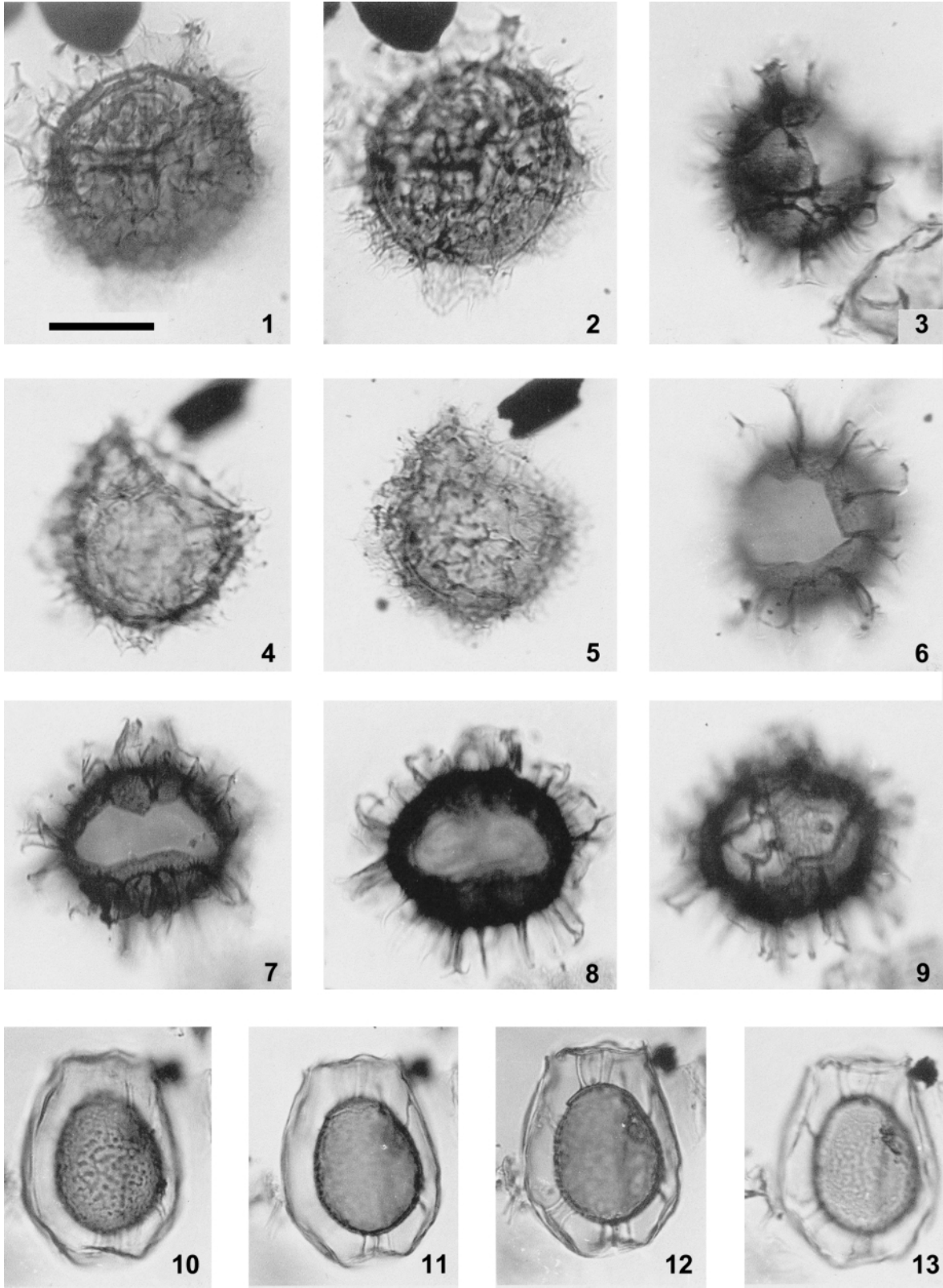
Diagnosis. Holocavate oval to ellipsoidal cyst with narrow pericoel. The grossly verrucose endophragm and the smooth or slightly stippled periphragm are connected by few processes in apical and antapical polar areas. Solid processes are slightly expanded distally. Apical archaeopyle (tA) with zig-zag margin, sulcal notch and free operculum.

Holotype. Turnhout – 933 m, preparation 3, coord. E.F. G37 (Pl. 1, figs 10–13).

Paratype. Turnhout – 933 m, preparation 4, coord. E.F. E43/1 (Pl. 2, fig. 5).

Type locality & horizon. Turnhout – 933 m. Campanian.

Dimensions. Holotype: length of pericyst (with operculum) – 70 µm, width of pericyst – 50 µm, length of endocyst – 46 µm, width of endocyst – 34 µm; paratype: length of pericyst (with operculum) – 64 µm, width of pericyst – 56 µm, length of endocyst – 40 µm, width of endocyst – 32 µm; other specimens (without operculum): length of pericyst – 60–65 µm, width of pericyst – 50–62 µm, length of endocyst – 40–50 µm, width of endocyst – 32–42 µm. Specimens measured: 7.



Stratigraphical occurrence. Beutenaken: sample 2–20 (Upper Campanian); Hallembaye: sample 4–74 (Lower Campanian–Upper Maastrichtian); Turnhout: –966 50 up to –759 89 m (Upper Campanian–Danian).

Stratigraphical and geographical distribution. Germany [Marheinecke (1986, 1992): Early–Late Maastrichtian; Kirsch (1991): Middle Maastrichtian]; Belgium [in Louwey (1991): Cenomanian–Campanian]; Belgium, Denmark and The Netherlands: Wilson (1971, 1974): Late Campanian–Late Maastrichtian (Ia–Vb Zone of Wilson, 1974)]. Denmark [Schjølter & Wilson (1993): Maastrichtian].

Remarks. *Leberidocysta chlamydata* subsp. *schjolerii* subsp. nov. differs from *Leberidocysta chlamydata sensu stricto* by the presence of processes connecting endo- with periphragm.

Genus *Nexosispinum* Davey, 1979

Nexosispinum? *complicatum* Slimani (1996)=*Pulchrasphaera minuscula* Schjølter *et al.* (1997)

(Pl. 3, figs 6–11)

?1986 Dinoflagellate type C in Ioannides: 41–42, pl. 24, figs 5, 7–9, 11, 12.

1996 *Nexosispinum?* *complicatum* sp. nov. Slimani: 377, pl. 3, figs D, E, pl. 4, figs H, J–N.

1997 *Pulchrasphaera minuscula* sp. nov. Schjølter *et al.*: 89, pl. I, figs 1–6, pl. II, figs 1–8.

1998 '*Nexosispinum?* *complicatum*' Slimani, 1996; Williams, Lentin & Fensome: 422.

Type species. *Nexosispinum hesperum* Davey, 1979.

Diagnosis. Proximate cyst with spherical to subspherical central body. Autophragm densely ornate by nontabular solid and short processes. Varied distal end of process: acuminate, bifid, digitate or complex and rarely connected. Probably a pre-cingular archaeopyle 2P(3",4"). Free operculum formed by loss of two paraplates.

Dimensions. Total diameter – 30–38 µm; length of processes – 1.5–8 µm. Specimens measured: 11.

Stratigraphical occurrence. Turnhout: –864 60 up to –739 31 m (Lower Maastrichtian–Danian).

Stratigraphical and geographical distribution. The Netherlands [Schjølter *et al.* (1997): Upper Maastrichtian of the ENCI Quarry, Maastricht].

Remarks. In 1996, *Nexosispinum?* *complicatum* was identified as a new species but not validly published, because the description was not given in Latin or English. *Nexosispinum?* *complicatum* and *Pulchrasphaera minuscula* Schjølter *et al.* (1997) are identified as the same species. Therefore, *Nexosispinum?* *complicatum* Slimani (1996) is junior synonym of *Pulchrasphaera minuscula* Schjølter *et al.* (1997).

Genus *Odontochitina* Deflandre, 1935; emend. Davey, 1970; emend. Bint, 1986

Odontochitina streelii sp. nov.

(Pl. 2, figs 1, 2; Pl. 3, fig. 5)

1996 *Odontochitina streelii* sp. nov. Slimani: 377–378, fig. 6, pl. 3, figs A–C.

1998 '*Odontochitina streelii?*' Slimani, 1996; Williams, Lentin & Fensome: 433.

Type species. *Odontochitina operculata* (O. Wetzel, 1933) Deflandre & Cookson, 1955.

Derivation of name. In honour of Prof. Dr Maurice Strel, Laboratory of Palaeontology, University of Liège, Liège, Belgium.

Diagnosis. Cornucavate cyst with three slender horns which are pointed at their distal end. Postcingular horn shorter than antapical horn. Periphragm and endophragm appressed between horns. Periphragm striated and tabulate by low crests, corniform gonyaulacoid paratabulation; 6 precingulars (2-1i), 5 precingulars (au-?e), 5-6 postcingulars (II-Vii), X sulcals, 1 antapical (Y) and 1 posterior intercalary. Slightly levorotatory paracingulum. Apical archaeopyle with circular and continuous margin and with free operculum. Number of apical paraplates not known because the operculum has not been observed.

Holotype. Beutenaken sample 20, preparation 1, coord. E.F. X28/3 (Pl. 2, figs 1, 2).

Paratype. Beutenaken sample 20, preparation 2, coord. E.F. F42/4 (Pl. 3, fig. 5).

Type locality & horizon. Beutenaken sample 20. Campanian.

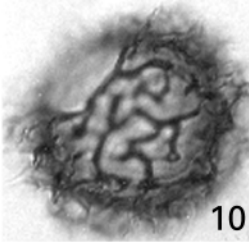
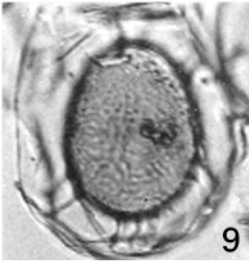
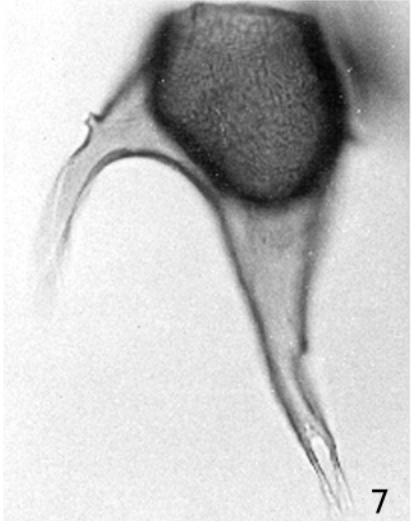
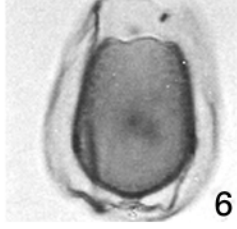
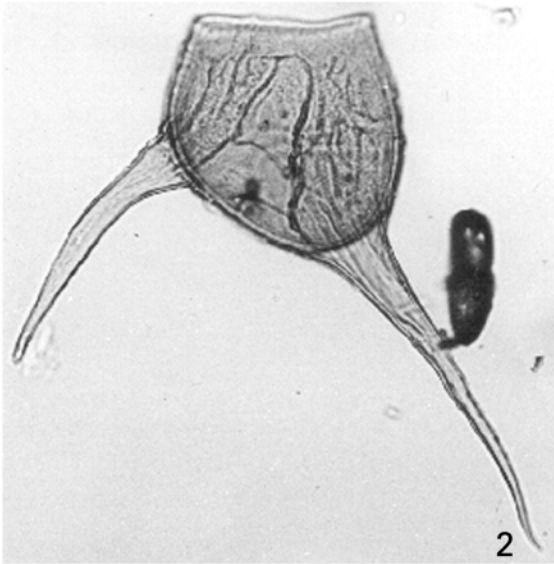
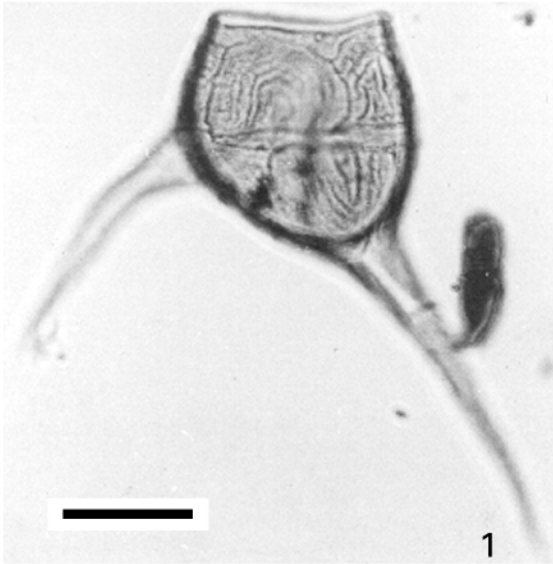
Dimensions. Holotype: length of central body (without operculum) – 66 µm, width of central body – 64 µm, length of lateral horn – 72 µm, length of antapical horn – 98 µm; paratype: length of central body (without operculum) – 46 µm, width of central body – 52 µm, length of lateral horn – 74 µm, length of antapical horn – 90 µm; other specimens: length of central body (without operculum) – 50–60 µm, width of central body – 50–60 µm, length of horns – 70–110 µm. Specimens measured: 7.

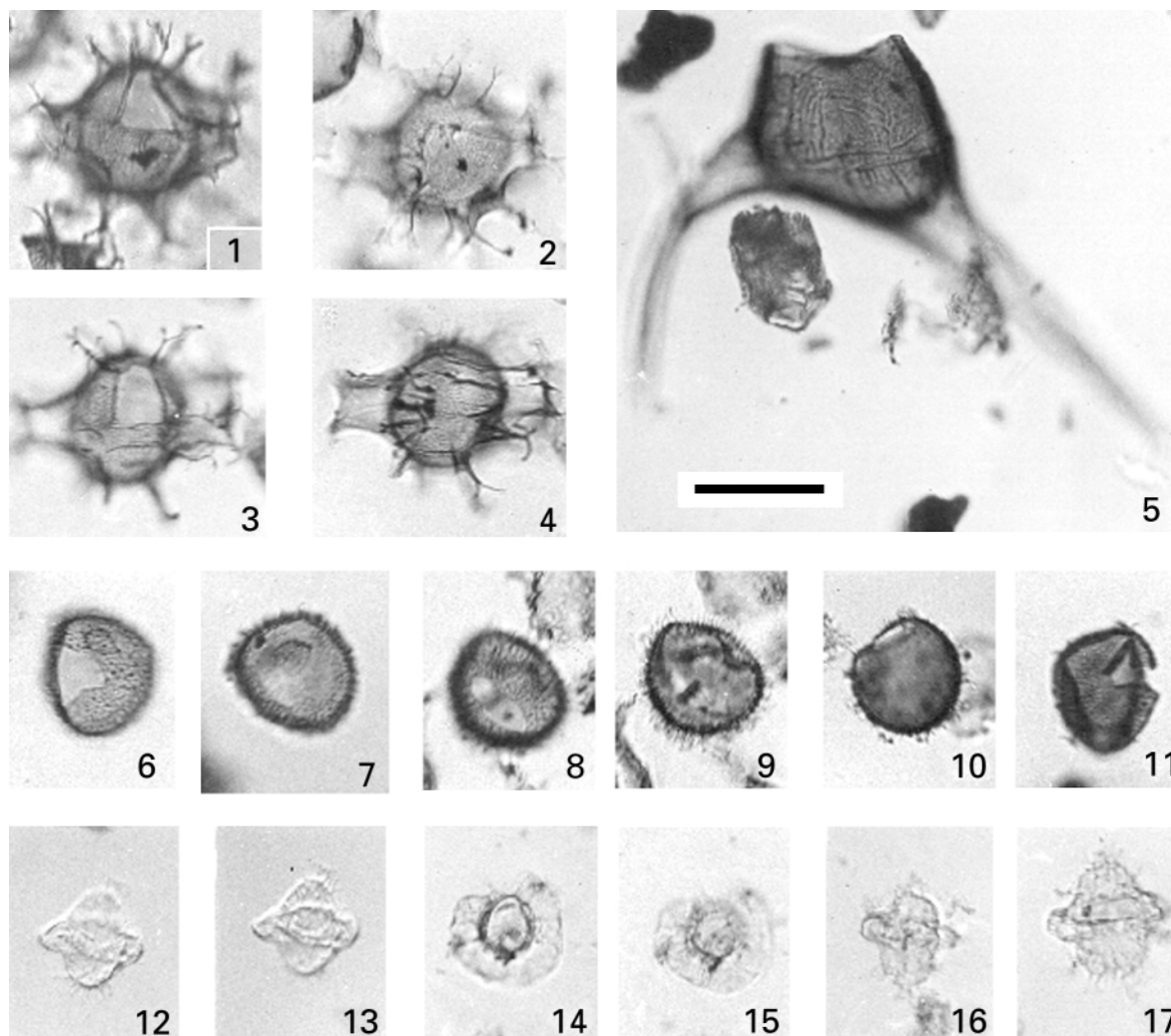
Stratigraphical occurrence. Beutenaken: sample 6–21 (Upper Campanian–Lower Maastrichtian); Turnhout: –933 up to –892 87 m (Upper Campanian–Lower Maastrichtian).

Remarks. *Odontochitina streelii* sp. nov. differs from *Odontochitina operculata* O. Wetzel (1933) by the striate ornamentation of the periphragm, indicating a tabulation. *O. streelii* sp. nov. differs from *Odontochitina wetzelii* sp. nov. and *Odontochitina* sp. A of Kirsch (1991) by its narrow, simple and often pointed horns, by its thinner and finely reticulate endophragm, by the absence of processes and by the striations of the periphragm. In *Odontochitina costata* Alberti (1961) the horns only are striate and they are, moreover, perforate.

Explanation of Plate 1

Figs 1,2,4,5. *Exochosphaeridium? masureae* sp. nov.: 1, holotype, Turnhout –956 m, preparation 8, E.F. V51/4, dorsal surface in high focus; 2, same specimen, ventral surface in low focus; 4, Turnhout –956 m, preparation 3, E.F. J24/(3), left lateral view in high focus; 5, same specimen, right lateral view in low focus. **Figs 3,6–9.** *Pervosphaeridium septatum* sp. nov.: 3, Turnhout –933 m, preparation 3, E.F. K43/1, left lateral view in high focus; 6, Turnhout –933 m, preparation 5, E.F. W39/4-X39/2, dorsal surface in high focus; 7, holotype, Turnhout –933 m, preparation 10, E.F. U33, dorsal surface in high focus; 8, same specimen, sectional focus on processes; 9, same specimen, ventral surface in low focus. **Figs 10–13.** *Leberidocysta chlamydata* (Cookson & Eisenack, 1962) Stover & Evitt, 1978 subsp. *schjolerii* subsp. nov.: 10, holotype, Turnhout –933 m, preparation 3, E.F. G37, high focus; 11,12, same specimen, sectional focus on processes and operculum; 13, same specimen, low focus. Scale bar=30 µm.





Explanation of Plate 3

Figs 1–4. *Spiniferites ramosus* (Ehrenberg, 1838) Loeblich Jr. & Loeblich III, 1966 subsp. *pteroceolus* subsp. nov.: **1**, holotype, Turnhout – 933 m, preparation 5, E.F. R41/3, dorsal surface in low focus; **2**, same specimen, ventral surface in high focus; **3**, paratype, Turnhout – 933 m, preparation 5, E.F. Q29, dorsal surface in low focus; **4**, same specimen, ventral surface in high focus. **Fig. 5.** *Odontochitina streealii* sp. nov.: paratype, Beutenaken sample 20, preparation 2, E.F. F42/4, dorsal surface in low focus. **Figs 6–11.** *Nexosispinum? complicatum* sp. nov.: **6**, Turnhout – 815 89 m, preparation 4, E.F. U48/4, dorsal surface in high focus; **7**, same specimen, ventral surface in low focus; **8**, Turnhout – 775 01 m, preparation 1, E.F. F27/4, dorsal surface in low focus; **9**, same specimen, ventral surface in high focus; **10**, Turnhout – 739 31 m, preparation 1, E.F. X48, sectional focus on processes; **11**, Turnhout – 815 89 m, preparation 1, E.F. Q54, dorsal surface with the two operculum pieces. **Figs 12–17.** *Stephodinium? spinosum* sp. nov.: **12**, holotype, Turnhout – 940 m, preparation 8, E.F. D53/2, ventral surface in low focus; **13**, same specimen, dorsal surface in high focus; **14**, Turnhout – 940 m, preparation 6, E.F. T40, sectional focus on equatorial pericoel; **15**, same specimen, polar surface in high focus; **16**, Turnhout – 940 m, preparation 8, E.F. F52/4-F53/3, right lateral view in low focus; **17**, Turnhout – 940 m, preparation 8, E.F. X45/4, dorsal surface in high focus. Scale bar=30 µm.

Explanation of Plate 2

Figs 1,2. *Odontochitina streealii* sp. nov.: **1**, holotype, Beutenaken, sample 20, preparation 1, E.F. X28/3, dorsal surface in low focus; **2**, same specimen, ventral surface in high focus. **Figs 3,4,7,8.** *Xenascus wetzeli* sp. nov.: **3**, holotype, Beutenaken, sample 2, preparation 1, E.F. E30/1, dorsal surface in low focus; **4**, same specimen, ventral surface in high focus; **7**, paratype, Hallembaye, sample 12, preparation 1, E.F. Q46/3, dorsal surface in low focus; **8**, same specimen, ventral surface in high focus. **Figs 5,6,9.** *Leberidocysta chlamydata* (Cookson & Eisenack, 1962) Stover & Evitt, 1978 subsp. *schioleerii* subsp. nov.: **5**, paratype, Turnhout – 933 m, preparation 4, E.F. E43/1, ventral surface in high focus; **6**, Turnhout – 933 m, preparation 2, E.F. U37, sectional focus on processes; **9**, Turnhout – 933 m, preparation 4, E.F. E34/3, low focus. **Fig. 10.** *Exochosphaeridium? masureae* sp. nov.: paratype, Hallembaye, sample 18, preparation 3, E.F. F32/3, dorsal surface in high focus. Scale bar=30 µm.

Genus *Pervosphaeridium* Yun, 1981*Pervosphaeridium septatum* sp. nov.

(Pl. 1, figs 3, 6–9)

1996 *Pervosphaeridium septatum* sp. nov. Slimani: 378–379, pl. 2, figs J–L, pl. 4, figs C, D.1998 '*Pervosphaeridium septatum*' Slimani, 1996; Williams, Lentin & Fensome: 476.**Type species.** *Pervosphaeridium pseudhystrichodinium* (Deflandre, 1937) Yun, 1981.**Derivation of name.** Septa connecting processes.**Diagnosis.** Spherical to subspherical chorate cyst with fibroreticulate autophragm. Numerous solid, thin and distally bifurcate processes with truncate to slightly capitate distal end. Distinct apical process often present. High membranous septa better developed around processes and connecting them laterally. Paratabulation indicated only by precingular archaeopyle 2P(3",4"). Free operculum formed by loss of two paraplates.**Holotype.** Turnhout –933 m, preparation 10, coord. E.F. U33 (Pl. 1, figs 7–9).**Type locality & horizon.** Turnhout –933 m. Campanian.**Dimensions.** Holotype: maximal diameter of central body – 60 µm, length of processes – 12–20 µm, height of septa – 8–18 µm; other specimens: maximal diameter of central body – 54–64 µm, length of processes – 12–22 µm, height of septa – 6–20 µm. Specimens measured: 10.**Stratigraphical occurrence.** Hallembaye: sample 1 (Lower Campanian); Turnhout: –987 up to –933 m (Lower Campanian–Upper Campanian).**Remarks.** *Pervosphaeridium septatum* sp. nov. differs from *Pervosphaeridium monasteriense* Yun (1981) by the high septa between the processes and by its more robust and bifurcate processes which are not as numerous as in *P. monasteriense*.Genus *Spiniferites* Mantell, 1850; emend. Sarjeant, 1970*Spiniferites ramosus* (Ehrenberg, 1838) Loeblich Jr. & Loeblich III, 1966 subsp. *pteroceolus* subsp. nov.

(Pl. 3, figs 1–4)

1996 *Spiniferites ramosus* (Ehrenberg, 1838) Loeblich Jr. & Loeblich III, 1966 subsp. *pteroceolus* sp. nov. Slimani: 379, pl. 3, figs H–J, pl. 4, figs E–G.1998 *Spiniferites ramosus* (Ehrenberg, 1838) Loeblich Jr. & Loeblich III, 1966 subsp. '*pteroceolus*' Slimani, 1996; Williams, Lentin & Fensome: 579.**Type species.** *Spiniferites ramosus* (Ehrenberg, 1838) Mantell, 1850.**Derivation of name.** Lateral pericoels resembling two wings (wing=pteron).**Diagnosis.** Chorate cyst with two subsquare lateral pericoels and subspherical endocyst. Densely granulate endophragm and smooth periphragm appressed between pericoels. Sexiform gonyaulacoid (S) paratabulation, indicated by parasutural septa and gonial and intergonial processes; 4 apicals (A,B,C and 1u), 6 precingulars (2-1i), 6 cingulars (au-e), 6 poscingulars (Iu-VI), X sulcals, 1 antapical (Y) and 1 posterior intercalarie (X). Trifurcate gonial processes and bifurcate intergonial processes with bifid to bifurcate distal end. Parasutural septa better developed

in areas where the endophragm and the periphragm are appressed. Strongly levorotatory paracingulum. Precingular archaeopyle P(3"). Free operculum formed by loss of one paraplate.

Holotype. Turnhout –933 m, preparation 5, coord. E.F. R41/3 (Pl. 3, figs 1, 2).**Paratype.** Turnhout –933 m, preparation 5, coord. E.F. Q29 (Pl. 3, figs 3, 4).**Type locality & horizon.** Turnhout –933 m. Campanian.**Dimensions.** Holotype: maximal diameter of endocyst – 34 µm, width of pericyst – 54 µm; paratype: maximal diameter of endocyst – 34 µm, width of pericyst – 60 µm; other specimens: maximal diameter of endocyst – 28–40 µm, width of pericyst – 50–70 µm. Specimens measured: 13.**Stratigraphical occurrence.** Beutenaken: sample 1,2 (Lower Campanian–Upper Campanian); Hallembaye: sample 1, 43 (Lower Campanian, Upper Maastrichtian); Turnhout: –987 up to –739 31 m (Lower Campanian–Danian).**Remarks.** *Spiniferites ramosus* subsp. *pteroceolus* subsp. nov. differs from *Spiniferites cruciformis* Wall & Dale in Wall *et al.* (1973) by its subspherical endocyst. The lateral pericoels mark the difference with *Spiniferites ramosus* subsp. *granomembranaceus* Davey & Williams (1966a). In *Rottnestia* the pericoels are observed in antapical and ventroapical position.Genus *Stephodinium* Deflandre, 1936; emend. Davey, 1970*Stephodinium? spinosum* sp. nov.

(Pl. 3, figs 12–17)

1996 *Stephodinium? spinosum* sp. nov. Slimani: 379–380, pl. 1, figs M–R.1998 '*Stephodinium? spinosum*' Slimani, 1996; Williams, Lentin & Fensome: 584.**Type species.** *Stephodinium coronatum* Deflandre, 1936.**Derivation of name.** Processes on the central body.**Diagnosis.** Small cavate cyst with ellipsoidal endocyst which is elongate in apical–antapical direction. Smooth to punctate periphragm and smooth endophragm appressed in apical and in antapical polar areas and in sulcal area. Equatorial pericoel interrupted ventrally. Cyst bearing thin, flexuous, solid or hollow and distally acuminate processes, except in the equatorial area where the endophragm and the periphragm are separated to form the pericoel. Paratabulation not indicated. Precingular archaeopyle P(3") rarely perceptible with adnate operculum.**Holotype.** Turnhout –940 m, preparation 8, coord. E.F. D53/2 (Pl. 3, figs 12, 13).**Type locality & horizon.** Turnhout –940 m. Campanian.**Dimensions.** Holotype: length of central body – 24 µm, width of central body – 18 µm, height of equatorial pericoel – 8 µm, width of equatorial pericoel – 8 µm; other specimens: length of central body – 24–32 µm, width of central body – 15–20 µm, height of equatorial pericoel – 6–10 µm, width of equatorial pericoel – 7–10 µm; length of processes – 4–9 µm. Specimens measured: 15.**Stratigraphical occurrence.** Turnhout: –987 up to –933 m (Lower–Upper Campanian).**Remarks.** The tabulation which characterizes *Stephodinium* is not observed in *Stephodinium? spinosum* sp. nov. The processes on the apical and antapical areas, and the ventral interruption of the equatorial pericoel, mark the differences with *Stephodinium*

Stage	CAMPANIAN			MAASTRICHTIAN			DANIAN
Substage	Early	Late		Early	Late		Early
Belemnite Zones (N.W. Europe)	<i>Goniolithus quadrata</i>	<i>Belemnitella mucronata</i>	<i>Belemnitella mucronata "minor"</i>	<i>Belemnitella "langei"</i>	<i>Belemnella lanceolata - Belemnella fastigata</i>	<i>Belemnitella junior</i>	<i>Belemnella casimirovensis</i>
new dinoflagellate species							

Fig. 5. Stratigraphic distribution of the new taxa.

pellucidum Deflandre (1943) and with *Stephodinium? parvum* De Coninck (1986).

Genus *Xenascus* Cookson & Eisenack, 1969; emend. Yun, 1981; emend. Stover & Helby, 1987

Xenascus wetzelii sp. nov.
(Pl. 2, figs 3, 4, 7, 8)

1971 *Odontochitina* sp. Wilson: pl. 2, figs 1, 2.

?1973 *Odontochitina costata* Alberti, 1961; Corradini: pl. 28, fig. 8.

1977 '*Odontochitina wetzelii*' Wilson, 1974; Schumacker-Lambry in Streel *et al.*: pl. 3, fig. 8.

1985 '*Odontochitina wetzelii*' Wilson, 1974; Foucher in Robaszynski *et al.*: figs 21, 22, pl. 10, figs 9, 10, 11, 12.

?1991 *Odontochitina* sp. A Kirsch: 46, pl. 24, figs 7, 8.

1996 *Xenascus wetzelii* sp. nov. Slimani: 380–381, fig. 7, pl. 3, figs F, G, Pl. 4, figs A, B.

1998 '*Xenascus wetzelii*' Slimani, 1996; Williams, Lentin & Fensome: 644.

Type species. *Xenascus australiensis* Cookson & Eisenack, 1969.

Derivation of name. In honour of Otto Wetzel who was one of the pioneers of Cretaceous dinocyst research in Germany.

Diagnosis. Cornucavate to circumcavate cyst with 1 apical, 1 antapical and 1 precingular horn. These are often bifurcate distally. The thick and microreticulate endophragm and thin and smooth periphragm are appressed between the horns. Corniforme gonyaulacoide paratabulation indicated by low parasutural crests and short gonial, solid or hollow, distally acuminate or bifurcate to trifurcate processes; 4 apicals, 6 precingulars (2-1i), X cingulars, 5 postcingulars (II-VI), X sulcals, 1 antapical and 1 posterior intercalarie (X). Paracingulum and parasulcus not subdivided. Apical archaeopyle with free operculum.

Holotype. Beutenaken sample 2, preparation 1, coord. E.F. E30/1 (Pl. 2, figs 3, 4).

Paratype. Hallembaye sample 12, preparation 1, coord. E.F. Q46/3 (Pl. 2, figs 7, 8).

Type locality & horizon. Beutenaken sample 2. Campanian.

Dimensions. Holotype: length of central body (without operculum) – 50 µm, width of central body – 54 µm, length of lateral horn – 54 µm, length of antapical horn – 66 µm; paratype: length of central body (without operculum) – 56 µm, width of central body – 54 µm, length of lateral horn – 60 µm, length of antapical horn – 84 µm; other specimens: length of central body (without operculum) – 53–60 µm, width of central body – 60–90 µm, length of the two horns – 90 µm; length of processes – 4–16 µm. Specimens measured: 8.

Stratigraphical occurrence. Beutenaken: sample 2–11 (Upper Campanian); Hallembaye: sample 1–33 (Lower–Upper Campanian); Turnhout: –966 50 up to –932 m (Upper Campanian.).

Stratigraphical and geographical distribution. Germany [Kirsch (1991): Early–Middle Campanian]; Belgium and the Netherlands [Wilson (1971, 1974): Late Campanian (*B. mucronata* Zone); Foucher in Robaszynski *et al.* (1985): Late Campanian (*B. mucronata* Zone)–Early Maastrichtian (*B. lanceolata* Zone)]; Belgium [Schumacker-Lambry in Streel *et al.* (1977) Late Campanian; in Louwye (1991): Campanian]; Italy [Corradini (1973): Senonian].

Remarks. *Xenascus wetzelii* subsp. nov. differs from *Xenascus esbeckianus* Yun (1981) by its reticulate (rather than granulate) endophragm, by its narrower and distally, often bifurcate, horns of which the postcingular and the antapical do not clearly communicate with each other.

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The stratigraphical distribution of the new taxa is summarized in Fig. 5. The restricted stratigraphical occurrence of

Pervosphaeridium septatum sp. nov. and *Stephodinium?* *spinosum* sp. nov. suggests that they are important stratigraphic species in the Campanian. The first and the last appearances of *Exochosphaeridium?* *masureae* sp. nov., *Xenascus wetzelii* sp. nov. and *Odontochitina streelii* sp. nov. and the first appearance of *Leberidocysta chlamydata* subsp. *schillerii* subsp. nov. are considered important stratigraphical markers for the Late Campanian. The first appearance of *Nexocispinium?* *complicatum* is within the Lower Maastrichtian.

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