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

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INTRODUCTION
Upper Cretaceous sediments have been sampled in the quarries of Beutenaken and Hallembeay (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
English. To meet this recommendation the present paper gives the diagnosis of the seven new taxa in English.

**SYSTEMATIC PALYNOLGY**

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** Peridiniales Haeckel., 1894  
**Genus** Exochosphaeridium Davey, Downie, Sarjeant & Williams, 1966b

*Exochosphaeridium? masureae* sp. nov.  
(Pl. 1, figs 1, 2, 4, 5; Pl. 2, fig. 10)  
1985a ‘Exochosphaeridium? acuminatum’ Wilson; Masure: fig. 1F.

1989 ‘Exochosphaeridium? acuminatum’ Wilson; Masure; Lentin & Williams: 133.  
1996 *Exochosphaeridium? masureii* sp. nov. Slimani: 373–374, pl. 1, figs H–L.  

**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. Periplagym 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.
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/p10) with 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.

Genus Leberidocysta Stover & Evitt, 1978

Leberidocysta chlamydata (Cookson & Eisenack, 1962) Stover & Evitt, 1978 subsp. schiolerii 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.


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 archeopyle (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.
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**Stratigraphical occurrence.** Beutenaken: sample 2–20 (Upper Campanian); Hallemby: sample 4–7 (Lower Campanian–Upper Maastrichtian); Turnhout: –966 50 up to –759 89 m (Upper Campanian–Danian).


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

Genus *Nexosispinum* Davey, 1979


(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. Schioler et al.: 89, pl. I, figs 1–6, pl. II, figs 1–8.


**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 precingular 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 [Schioler 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* Schioler et al. (1997) are identified as the same species. Therefore, *Nexosispinum? complicatum* Slimani (1996) is junior synonym of *Pulchrasphaera minuscula* Schioler et al. (1997).


*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 Streel, 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-Ii), 5 precingulars (au-2e), 5–6 postcingulars (II-VII), X sulcalis, 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.


**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 wettzlensis* 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.

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**Explanation of Plate 1**

Figs 1, 2, 4, 5. *Exoschacharadium? masurae* 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. *Pervoschacharadium 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-W39/2, 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 chilydata* (Cookson & Eisenack, 1962) Stover & Evitt, 1978 subsp. schioleri 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.
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Explanation of Plate 3

Figs 1–4. *Spiniferites ramosus* (Ehrenberg, 1838) Loeblich Jr. & Loeblich III, 1966 subsp. *pteracoelus* subsp. nov.: 1, holotype, Turnhout −933 m, preparation 5, E.F. R4/3, 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 in low focus; 4, same specimen, ventral surface in high focus. Fig. 5. *Odontochitina streelii* 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, dorsal surface in high focus; 13, Turnhout −940 m, preparation 6, E.F. T40, sectional focus on equatorial pericoel; 14, 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 streelii* 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 wetzelii* 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 ohlyndotata* (Cookson & Eisenack, 1962) Stover & Evitt, 1978 subsp. *schulzeri* 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 pseudohystrichodinium* (Deflandre, 1937) Yun, 1981.

1998 ‘*Pervosphaeridium septatum*’ Slimani, 1996; Williams, Lentin & Fensome: 476.

**Diagnosis.** Spherical to subspherical chorate cyst with fibro-reticulate autophagm. Numerous solid, thin and distally bifurcate processes with truncate to slightly capitulate distal end. Distinct apical process often present. High membranous septa better developed around processes and connecting them laterally. Paratabulation indicated only by precingular septa. High reticulate autophragm. Numerous solid, thin and distally acuminate processes, except in the equatorial area where the endophragm and the periphagm are appressed. Strongly levorotatory paracingulum. Precingular archaeopyle P(3’). Free operculum formed by loss of two paraplates.

**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.


**Stratigraphical occurrence.** Beutenaken: sample 1.2 (Lower Campanian–Upper Campanian); Hallembeke: sample 1, 43 (Lower Campanian, Upper Maastrichtian); Turnhout: – 987 up to – 739 31 m (Lower Campanian–Danian).

**Remarks.** *Spiniferites ramosus* subsp. *pterocoeus* 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 *Rottneista* the pericoels are observed in antapical and ventralopical 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.


**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 periphagm and smooth endophagm 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 endophagm and the periphagm 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.


**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*
**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. ‘*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 gonal, 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 intercalaire (X). Paracingulum and parasulcus not subdivided. Apical archaeocype with free operculum.  

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

**Paratype.** Haltembeaye 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); Haltembeaye: sample 1–33 (Lower–Upper Campanian); Turnhout: –966 50 up to –932 m (Upper Campanian).  


**Remarks.** *Xenascus wetzelii* subspp. 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 postcingulum and the antapical do not clearly communicate with each other.  

**DINOFLAGELLATE STRATIGRAPHY**

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? masareae sp. nov., Xenascus wettzeli sp. nov. and Odontochitina streelii sp. nov. and the first appearance of Leberidycysta chlamydata subsp. schleri sp. nov. are considered important stratigraphical markers for the Late Campanian. The first appearance of Nectocispinum? complicatum is within the Lower Maastrichtian.

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