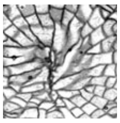
Viséan Lithostrotionidae (Rugosa) from Zonguldak and Bartın (NW Turkey)

Julien Denayer



In Northwestern Turkey, the Mississippian (Lower Carboniferous) Yılanlı Formation is composed of variegated shallow-water limestone containing rugose corals, tabulate corals and brachiopods. Six sections were sampled in the Zonguldak and Bartın areas, from east to west, there are Süzek, Topluca, Gökgöl, Kokaksu, Ulutam and Kisla sections. Among the rugose corals, a rich and diversified assemblage of Lithostrotionidae has been collected. The latter contains the species: *Nemistium* cf. *affine*, *Siphonodendron ondulosum*, *S. martini*, *S. irregulare*, *S. pauciradiale*, *S. asiaticum*, *S. rallii* sp. nov., *S. scaleberense*, *S. kleffense*, *S.* aff. *kleffense*, *Lithostrotion araneum, L. vorticale, L.* sp. and *L. potii* sp. nov. During the Moliniacian it is proposed that subcerioid colonies of *S. ondulosum* gave rise to cerioid colonies of *Lithostrotion potii* sp. nov., the latter constituting the oldest species of the genus previously considered to be Livian to Warnantian in age. This discovery led to an emendation of the phyletic lineage of the Lithostrotionidae. The biostratigraphy based on rugose corals indicates a Moliniacian (early Viséan) and Warnantian (late Viséan) age of the deposits with the absence of the intervening Livian (middle Viséan). • Key words: Lower Carboniferous, Viséan, Pontides, Turkey, rugose corals, *Lithostrotion*, *Siphonodendron*, *Nemistium*.

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The lithostrotionids, namely the cerioid *Lithostrotion* and phaceloid *Siphonodendron,* are probably the most abundant and widespread colonial rugose coral genera of the Viséan. They have been described from Belgium (Poty 1981, 1984), Brittany (Vuillemin 1990), N France (Poty & Hannay 1994), British Isles (Nudds 1979, Semenoff-Tian-Chansky & Nudds 1979), Poland (Khoa 1977), S France (Aretz 2002), S Spain (Rodríguez & Falces 1992, Rodríguez *et al*. 2002), N Africa (Semenoff-Tian-Chansky 1985, Aretz 2010, Aretz & Herbig 2010, Rodríguez *et al*. 2013), S Turkey (Denayer 2012), Ukrainian Donets Basin (Vassiljuk 1960), Siberian Omolon (Conil *et al.* 1982), Kuznetsk Basin (Dobroljubova *et al*. 1966), Japan (Minato 1955), SE China (Fan *et al*. 2003) and W China (Lin & Rodriguez 1993). Australian (Jull 1974, Webb 1990) and Canadian (Bamber 1966) forms are homeomorphic taxa evolving in a distinct stock of "lithostrotionid" corals (Webb 1994, Fedorowski 2008, Poty 2010). Both require revision.

In NW Turkey, some lithostrotionid corals were first noticed by Ralli (1895) and Tokay (1954) then described by Charles (1933) in his regional study of Zonguldak and Bartın. He figured three *Siphonodendron* species: under the names *Lithostrotion martini*, *Lithostrotion* aff. *irregulare* and *Lophophyllum fraiponti* nov. sp. Charles's collection and newly collected material from Charles's localities around Bartın and Zonguldak are described in the present paper. The family is richer than noticed in previous papers (Charles 1933, Ünsalaner-Kiragli 1958, Dîl & Konyali 1978, Denayer 2011). Moreover, Turkish specimens are clear Eurasian lithostrotionids and most of them belong to well-established W European species. Their stratigraphic distribution also matches that of W Europe, thus the use of Belgian substage names (as proposed by Poty *et al*. 2013a) is justified.

Geological settings

The northern part of Turkey – the Pontides – is composed of two tectonic units: the Istanbul-Zonguldak Zone and the Sakarya Zone, separated from each other by a major fault named the Intra-Pontide "Suture" (Fig. 1). Göncüoğlu *et al*. (1997) divided the Istanbul-Zonguldak Zone into the

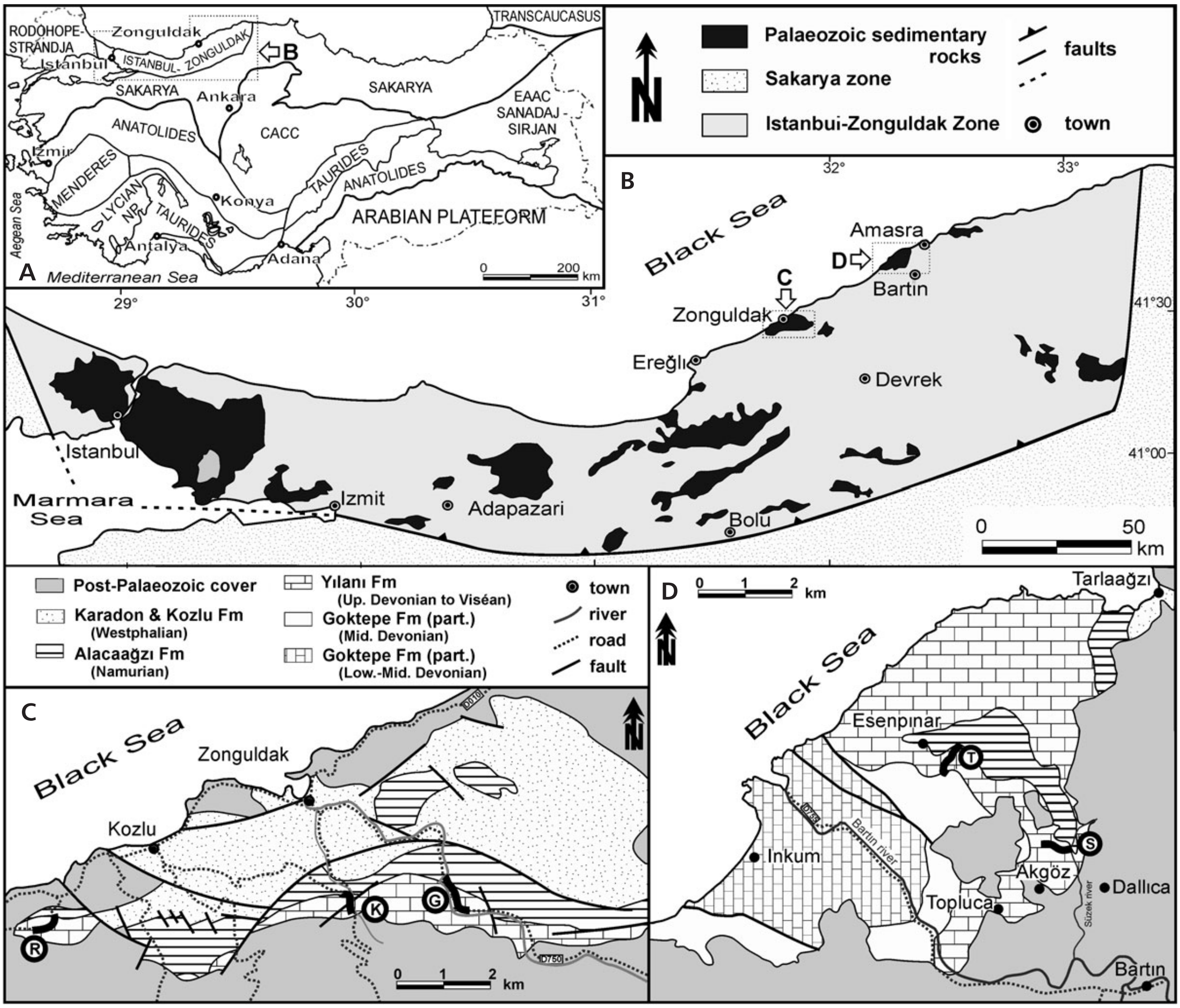


Figure 1. A – general structural map of Turkey (modified after Görür & Tüysüz 2001, Moix *et al*. 2008 and Okay 2008). • B – geological map of the Istanbul-Zonguldak Zone (modified after Okay *et al.* 2006) with the position of the Zonguldak and Bartın areas. • C – simplified geological map of the Zonguldak area (redrawn after Hoşgörmez 2007 and Charles 1933) with the location of the sampled sections (G – Gökgöl section, K – Kokaksu section, U – Ulutam, R – Kisla section). • D – simplified geological map of the Bartın area (redrawn after Tokay 1954) with the location of the sampled sections (T – Topluca section, S – Süzek section). Abbreviations: CCAC – Central Anatolian Cristalline Complex, EAAC – East Anatolian Accretionnary Complex, Lycian Np. – Lycian Nappes.

Istanbul Terrane and Zonguldak Terrane. However, this hypothesis is not unanimously accepted (*e.g*. Okay *et al*. 2006) and the alternative concept interpreted the Istanbul and Zonguldak areas as the two sides of one single terrane. The Istanbul Zone recorded basinal sediments during Devonian and Carboniferous times while the Zonguldak Zone shows shallow-water facies.

In the Istanbul Zone, the Carboniferous is represented by the Baltalimanı (Tournaisian), Trakya (Tournaisian-Viséan) and Gümüşdere (Namurian) formations representing Paeckelmann's (1938) "Thrazische Serie". The Trakya Formation is dominated by siliciclastics and only two limestone lenses are known: the Heybeliada Limestone (lower Viséan, Mamet 1973) and Cebecikoy Limestone (lower Viséan after Okuyucu *et al.* 2013 or middle Viséan after Mamet 1973). These limestones possibly correspond to olistoliths (Özgül 2012, Okuyucu *et al.* 2013). The Viséan corals from Istanbul are almost unknown, only Erentöz (1966) indicates the occurrence of *Syringopora* and *Siphonodendron*.

In the Zonduldak Zone (Zonguldak and Bartın areas, Fig. 1C, D), the Yılanlı Formation includes all the carbonate rocks of Devonian and Carboniferous age. The Lower Carboniferous succession is exposed almost continuously in the Kokaksu, Gökgöl and Kisla sections (Zonguldak vicinity) and along the discontinuous Topluca and Süzek sections (Bartın vicinity). The Yılanlı Formation consists of variegated limestones, often cherty or silicified and rich in macrofauna.

The Kokaksu section is situated in the riverbed of the Kokaksu Creek, near the Çaydamar hamlet, 2 km south of Zonguldak town (41°25´ 59.72˝ N 31°48´ 25.40˝ E, K in Fig. 1C). Specimens collected by F. Charles in the 1930's came from outcrops destroyed by building works along the creek. The Viséan part of the Yılanlı Formation is exposed downstream at a small bridge. The lower 30 m are made of cherty thin-bedded bioclastic and fossiliferous limestone with numerous syringoporids, *Dorlodotia briarti* and *Palaeosmilia murchisoni* (Fig. 2). Cherts increase in size and frequence up-section, together with thickness of the limestone beds. The following unit (60 m-thick) is the most fossiliferous of the section and includes brachiopods, gastropods, syringoporids and large colonies of *Dorlodotia*, *Ceriodotia* and *Siphonodendron*. The *Ceriodotia bartinensis* horizon is separated from the *C. petalaxoides* horizon by a 2 m-thick package of dark silicified limestone. These two horizons are repeated by a longitudinal fault. Foraminifers from these units indicate the uppermost Moliniacian (MFZ11B of Hance *et al.* 2011). The rest of the section is dominated by thick-bedded limestone, usually dark and silicified. The dominant facies are bioclastic packstones and grainstones with abundant brachiopods, gastropods and corals. Large colonies (> 1 m in diameter) of *Siphonodendron* are common, together with numerous *Palaeosmilia*, *Aulophyllum* and *Koninckophyllum*. *Palastraea konincki* (Charles, 1933) is also present. Corals and foraminifers indicate a Warnantian age. The upper part of the section is made of chert beds alternating with siltstone and sandstone belonging to the Alacaağzı Formation (uppermost Viséan to Serpukhovian, Dîl *et al.* 1976). Both foraminifers and rugose corals indicate the lack of Livian (middle Viséan) deposits while sequence stratigraphy (Denayer, in prep.) confirms this absence.

The Gökgöl section is situated along the road D750 Devrek-Zonguldak, upstream the Asma hamlet, 4 km south of Zonguldak (41°26´ 19.28˝ N–31°50´ 05.43˝ E, G in Fig. 1C). Moliniacian units crop out near the cave entry with facies similar to those observed in the Kokaksu section. *Dorlodotia briarti*, *D. euxinensis*, *Ceriodotia bartinensis* and *Siphonodendron ondulosum* are abundant. The rest of the succession is exposed nearby in a disused quarry. The Warnantian part of the section is dominated by medium- then thick-bedded grey cherty bioclastic limestone (mainly packstone and grainstone) with an abundant and diversified coral fauna: *Siphonodendron*, *Lithostrotion*, *Koninckophyllum*, *Palastraea* and syringoporids (Fig. 2). Brachiopods are locally abundant. Foraminifers indicate the late Viséan (MFZ13–14–15?), as do the corals (RC7–8 biozones of Poty *et al*. 2006). The contact with the Namurian shale is sharp and the facies alternation observed in Kokaksu is not developed here.

The Kisla section is located along a small road, 3 km SW of Zonguldak (41°24´ 58.01˝ N–31°43´ 12.53˝ E, R in Fig. 1C). The Moliniacian is poorly exposed (some beds with *Dorlodotia*) while the Warnantian yielded the colonial *Siphonodendron*, *Lithostrotion*, *Nemistium* and *Palastraea* genera.

In the Bartın area, the Topluca and Süzek sections were sampled. The Topluca section is situated 7 km northwest of Bartın town, along a new track created between the Topluca earth pit and the valley road (41°41´ 15.41˝ N–32°17´ 00.54˝ E, T in Fig. 1D). The Viséan part of the Yılanlı Formation is discontinuously exposed. Moliniacian corals are only known from scree blocks. The Warnantian, exposed in the northern part of the section, is dominated by thick-bedded bioclastic grainstones and rudstones (Fig. 2). The corals are numerous but less diversified than in the previous localities: *Siphonodendron* species are the only colonial corals, the solitary belonging to *Palaeosmilia*, *Clisiophyllum* and *Koninckophyllum*.The limestone is topped by an erosive disconformity capped by a conglomeratic horizon made of weathered cherts embedded in shale. The latter is overlain by the Alacaağzı Formation siliciclastics.

The Süzek section (Süzek Deresi in Tokay 1954) is situated in the western flank of the valley, 1 km NW of Dallıca near Bartın (41°40´ 04.72˝ N–32°18´ 58.19˝ E, S in Fig. 1D). Strata are inverted. The Moliniacian crops out in the top of the hill and exposes bioclastic facies particularly rich in corals: *Dorlodotia*, *Ceriodotia*, *Siphonodendron*, *Lithostrotion*, *Clisiophyllum*, *Palaeosmilia*, and syringoporids. Warnantian limestones are poorly exposed and its fauna is mainly known from scree and loose blocks near the river. As in the previous section, the limestones are capped by a disconformity upon which lie the Namurian siliciclastics (Fig. 2).

Material and methods

The newly collected material is housed in the Laboratory of Animal and Human Palaeontology, Department of Geology, University of Liège in Belgium (collection P.ULg). Charles's specimens are housed in the Invertebrates collection in the Royal Belgian Institute of Natural Sciences, Brussels (IRSNB) under numbers IP-10861 and IP-15123. Abbreviations: TS – transverse section, LS – longitudinal section. Localitites: G – Gökgöl, K – Kokaksu, R & S – Kisla, ET – Topluca, SR – Süzek. Authors: M.-E. & H. – Milne-Edwards & Haime, S.-T.-C. – Semenoff-Tian-Chansky, Y. & H. – Yabe & Hayasaka.

Systematic palaeontology

Subclass Rugosa Milne-Edwards & Haime, 1850
Order Stauriida Verrill, 1865
Family Lithostrotionidae d'Orbigny, 1852
Subfamily Lithostrotioninae d'Orbigny, 1852

Genus *Siphonodendron* McCoy, 1849

Type species. – *Lithodendron pauciradialis* McCoy, 1844, Viséan, Ireland.

Diagnosis. – Fasciculate coral with cylindrical corallites. Major septa long, reaching or not the axis. Minor septa developed in the dissepimentarium or entering slightly the tabularium. Axial structure made of a styliform columella bearing rare short septal lamellae. Columella often connected to the counter and/or cardinal septa. Diphymorphic corallites occasionally occur. Cardinal fossula poorly conspicuous. Dissepimentarium made of interseptal dissepiments concentric, V-shaped or herringbone, lacking in small-sized species. Tabulae complete or not, cone-, tent-, bell- or mesa-shaped in diphymorphic specimens. Increase lateral, non-parricidal. Modified from Poty (1981).

Discussion. – The characters of *Siphonodendron* being simple, they have been recognized in several groups of coral. Unfortunately, all of them were described under the same generic name. Works by Fedorowski (2008), Fedorowski & Bamber (2007), Jull (1965), Nudds (1979), Poty (1975a, 1981, 1984, 1993, 2010), Scrutton (1983), Semenoff-Tian-Chansky & Nudds (1979), Rodríguez *et al*. (2002), Webb (1990, 1994) – among others – showed that at least three distinct stocks of corals evolved in parallel and bear the name and the characters of *Siphonodendron*. 1) *Siphonodendron sensu stricto*, common in Eurasia and N Africa. Turkish *Siphonodendron* belong to this first group. 2) Australian "*Siphonodendron*" bearing long major septa connected to a strong columella and having differentiated axial and periaxial series of tabellae. They seem to appear earlier than *Siphonodendron sensu stricto* (late Tournaisian? Webb 1990 – but their age needs to be checked), and their evolution followed different trends (Pickett 1966, Webb 1994). 3) N American "*Siphonodendron*" having short septa and an inconstant weak columella which is not related to the counter septum (Fedorowski & Bamber 2007). Their morphological variability is wide (Sando 1965). They appear in the Tournaisian but are not known after the middle part of the Viséan (Sando 1970). A fourth group needs to be cited here: the corals described in the Lower Carboniferous of the Russian Platform by Dobroljubova (1958) under the name *Siphonodendron* but showing a parricidal increase. They probably belong to the genus *Nemistium* Thomson & Nicholson, 1876.

***Siphonodendron asiaticum* (Yabe & Hayasaka, 1915)**
Figure 3A–H

1915 *Lithostrotion irregulare* var. *asiatica* Yabe & Hayasaka; p. 57.
* ?1920 *Lithostrotion irregulare* var. *asiatica* Y. & H. – Yabe & Hayasaka, pl. 10, fig. 2, pl. 11, fig. 7.
1933 *Lithostrotion* (*S.*) *irregulare* var. *asiatica* Y. & H. – Yü, p. 95, pl. 29, figs 3, 4, pl. 20, fig. 1.
1933 *Lithostrotion* aff. *irregulare* (Phillips). – Charles, p. 138, pl. IV, fig. 4.3
1937 *Lithostrotion irregulare* var. *asiatica* Y. & H. – Yü, p. 95, pl. 29, figs 3, 4, pl. 20, fig. 1.
1958 *Lithostrotion junceum* (Fleming). – Ünsalaner-Kiragli, p. 57, pl. 12, fig. 1.
1960 *Lithostrotion asiatica* Y. & H. – Vassiljuk, p. 79, pl. 19, fig. 2. [*cum syn*.]
1962 *Lithostrotion irregulare* var. *asiatica* Y. & H. – Yü *et al*., p. 73, pl. 21, fig. 2.
1976 *Siphonodendron* ex. gr. *irregulare* (Phillips). – Dîl *et al*., p. 408, pl. I, fig. 2
1978 *Lithostrotion irregulare* var. *asiatica* Y. & H. – Fan, p. 168, pl. 64, fig. 7.
1989 *Lithostrotion irregulare* var. *asiatica* Y. & H. – Wu & Zhao, p. 106, pl. 24, fig. 1.
non 2003 *Lithostrotion irregulare asiatica* Y. & H. – Fan *et al*., p. 321, pl. 40, fig. 2.

Holotype. – Yabe & Hayasaka (1915) did not appoint any holotype, no lectotype was chosen and the systematic position (species, subspecies and variety coexist in the literature) was never precisely established. Vassiljuk's (1960) opinion to consider *asiaticum* as a valid species is followed here.

Material. – 20 colonies: 3 from Kokaksu section, 6 from Gökgöl, 6 from Süzek, 3 from Topluca and 2 from Amasra (Ralli's collection).

Diagnosis. – Phaceloid *Siphonodendron* with small corallite having a mean diameter of 2.9 mm and 16 septa of both orders. Major septa usually connected to the columella. Minor septa half as long as the major. Dissepimentarium composed of one single row of interseptal dissepiments. After Yabe & Hayasaka (1915) and Fan *et al*. (2003).

Description. – Several colonies, observed in the Kokaksu section, reach 50 to 60 cm in diameter and height. They are mainly phaceloid with supporting processes,

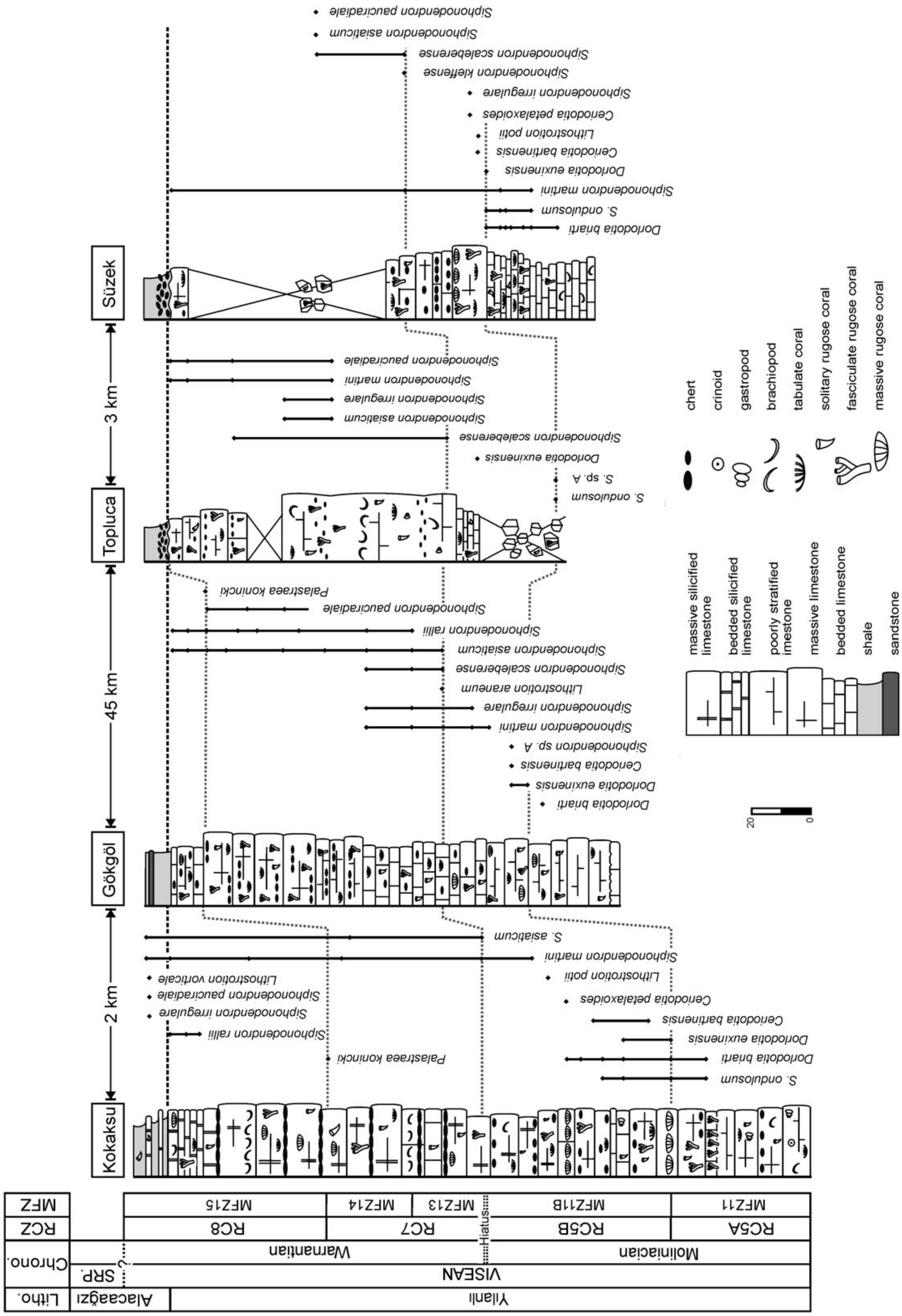


Figure 2. Simplified litho- and biostratigraphy of the main sampled sections with the stratigraphic range of the lithostrotionids species and other colonial rugose corals in the Yılanlı Formation. Rugose coral biozones (RCZ) after Poty *et al.* (2006), except subzones RC5A–RC5B (see main text). Foraminiferal biozones (MFZ) after Poty *et al.* (2006) and Hance *et al.* (2011). Abbreviations: Litho. – lithostratigraphy (formations), Chrono. – chronostratigraphy (stage, substages), SRP. – Serpukhovian.

but some colonies show a subcerioid trend and prismatic corallites (Fig. 3H). The corallites are cylindrical their external wall bears septal grooves and ridges (Fig. 3A). Transverse section: The mature corallites have a mean diameter of 2.9 mm (maximum 4 mm) and possess 16 septa of both orders (maximum 20, Fig. 4). The major septa are long and usually connected to the columella or withdrawn from the axis and create a free zone up to 1.5 mm large in the centre of the tabularium. Minor septa are 1/3 to 1/2 as long as the major and commonly enter into the tabularium. They are reduced to septal crests on the external wall in some specimens. The columella is 0.75–1 mm long, often thickened (up to 0.5 mm) and bears short spiny septal lamellae confluent with the major septa. The columella is commonly connected to the counter septum, rarely to the cardinal one. Diphymorphic corallites are frequent (Fig. 3C). The cardinal fossula is seldomly conspicuous. The dissepimentarium comprises only one row of small interseptal dissepiments, less than 1 corallite in 100 shows an incomplete second row. The external wall is straight but thick (up to 0.25 mm). Longitudinal section: The tabulae are complete, upturned towards the columella (Fig. 3Fb–c), horizontal and complete in diphymorphic corallites. The dissepiments are small, 0.2 mm long and 0.4 mm high, arranged in vertical rows. There are on average 20 tabulae and 30–40 dissepiments per centimetre height.

Discussion. – Morphological characters of *Siphonodendron asiaticum* are similar to those of *Siphonodendron junceum* (Fleming, 1828) but the occurrence of a single row of dissepiments allows an easy distinction of the two species, the dissepimentarium is lacking in the latter. The radial pattern of septa and their confluence with the columella is very similar to that observed in *S. junceum.* Nevertheless, the small spiny septal lamellae attached to the columella (Fig. 3Fe) – a common character of large species of the genus – is not observed within *S. junceum*. *S. asiaticum* differs from *S. pauciradiale* by smaller dimension and a lower number of septa.

Occurrence. – In China, the species is known in the late Viséan of Guangzi and Anhuei Province (Yü 1933) as well as in Hunan and Yunnan (Yabe & Hayasaka 1915). In the Donets Basin (Vassiljuk 1960), *S. asiaticum* is known in C^{V}_{1f}, horizon (late Viséan). Up to now, the species has been described neither in W Europe nor in N Africa. *S. asiaticum* is abundant in Bartın and Zonguldak area, in the Warnantian (MFZ13–MFZ14 foraminiferal biozones of Poty *et al.* 2006).

Siphonodendron pauciradiale (McCoy, 1844)
Figure 3I–K

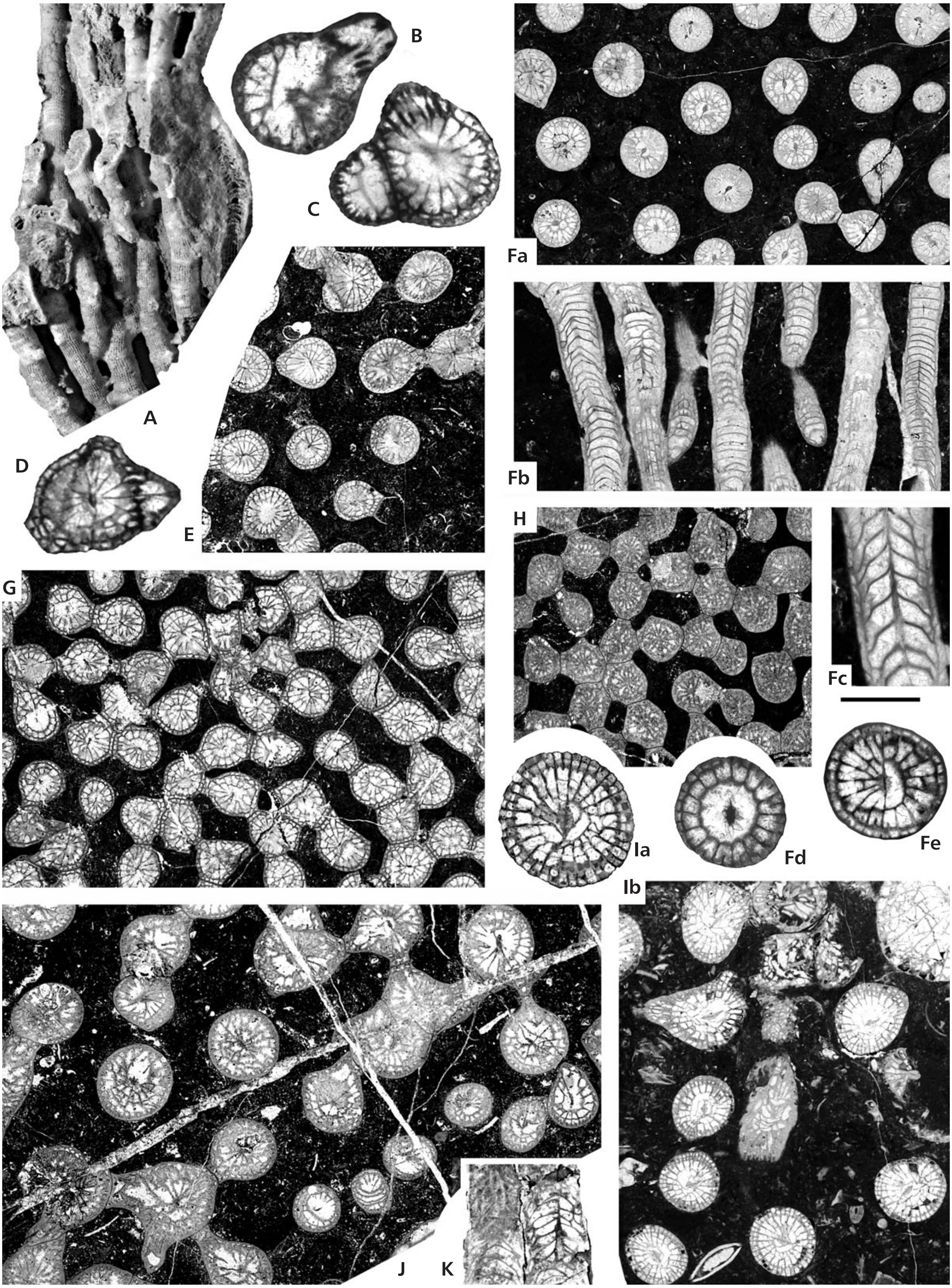
*1844 *Lithodendron pauciradialis* McCoy; p. 189, pl. 27, fig. 7.
2005 *Siphonodendron pauciradiale* (McCoy). – Aretz & Nudds, p. 176. [*cum syn.*]
2005 *Siphonodendron pauciradiale* (McCoy). – Cózar *et al.*, p. 38, figs 10, 12.
2007 *Siphonodendron pauciradiale* (McCoy). – Rodríguez & Somerville, p. 278, pl. 1, fig. 8.
2009 *Siphonodendron pauciradiale* (McCoy). – Rodríguez & Said, p. 10, pl. 1, figs 3-4.
2010 *Siphonodendron pauciradiale* (McCoy). – Aretz, p. 32, fig. 5e.
2010 *Siphonodendron pauciradiale* (McCoy). – Aretz & Herbig, p. 302, fig. 6b.
2011 *Siphonodendron pauciradiale* (McCoy). – Denayer *et al.*, p. 171, pl. 10, fig. F.
2012 *Siphonodendron pauciradiale* (McCoy). – Denayer; p. 324, fig. 7E.
2012 *Siphonodendron pauciradiale* (McCoy). – Lin *et al.*, p. 334, pl. 2, figs I–K, pl. 3, figs A, B.
2012 *Siphonodendron pauciradiale* (McCoy). – Somerville *et al.*, p. 311, fig. 3A.
2013 *Siphonodendron pauciradiale* (McCoy). – Said *et al.*, p. 374, fig. 5H.

Lectotype. – Specimen 82-1925, Glencar Limestone (Asbian), Magheramore, Tobercurry, County Sligo, Ireland; Griffith Collection, National Museum of Ireland, Dublin.

Material. – 13 fragments of colonies: 5 from Gökgöl section, 2 from Kokaksu, 1 from Amasra (coll. Ralli), 4 from Topluca and 1 from Süzek.

Diagnosis. – Dendroid or phaceloid *Siphonodendron.* Corallites 4 mm in diameter, having 18–20 septa of both orders. One or two rows of interseptal dissepiments, rarely up to 4. After Poty (1981).

Figure 3. A–H – *Siphonodendron asiaticum* (Yabe & Hayasaka, 1915). • A – specimen SR.7.14 from Süzek section, external view (× 2); B – K.12.2 from Kokaksu, TS in an offsetting corallite (× 6); C – ET.2.5 from Topluca, TS in an offsetting corallite (× 6); D – ET.2.5b from Topluca, TS in an offsetting corallite (× 6); E – ET.2.2 from Topluca, TS (× 3); F – K.9.1 from Topluca, Fa – TS (× 3), Fb – LS (× 3), Fc – closer view of LS (× 6); G – ET.2.5 from Topluca, TS (× 3); H – G.5.4 from Gökgöl, TS (× 3). • I–K – *Siphonodendron pauciradiale* (McCoy, 1849). • I – SR.7.1 from Süzek, Ia – TS (× 6), Ib – TS (× 3); J – ET.1.5 from Topluca, TS (× 3); K – G.16.3 from Gökgöl, LS (× 3). All specimens are Warnantian (Late Viséan). Scale bar equals 7.5 mm for A, 5 mm for E, Fa, Fb, G, H, J, K and 2.5 mm for B–D, Fc–Fe, Ia.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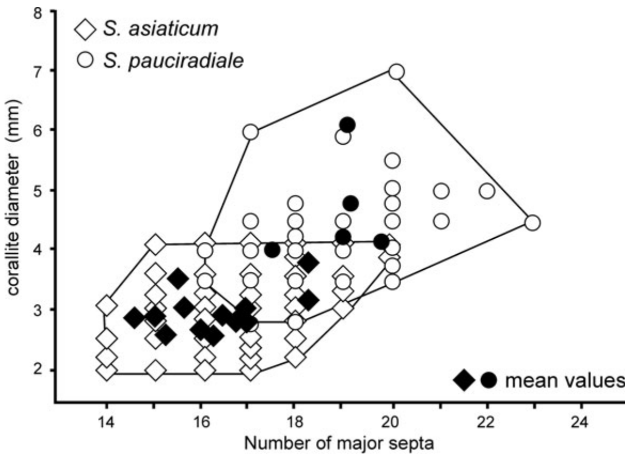


Figure 4. Scatter diagram showing the number of major septa plotted against corallite diameter for *Siphonodendron asiaticum* (Yabe & Hayasaka, 1915) and *Siphonodendron pauciradiale* (McCoy, 1849), based on 280 and 40 measurements, respectively. The mean values are given for each colony.

Description. – Transverse section: The corallites have a mean diameter of 4.3 mm (maximum 7 mm, Fig. 4). The mean tabularium diameter is 3.7 mm (maximum 4.5 mm). There are 19 septa of both orders on average (maximum 24). The latter are thick and measure 1/3 to 1/4 of the corallite radius. The cardinal septum is often shorter. The minor septa are restricted to the dissepimentarium. The columella is 0.8–1 mm long, usually thickened with a rounded section. Some rare thin septal lamellae are sometimes present. In the juvenile stages, the columella is connected to the counter septum and/or to the axial ends of other major septa. In mature stages, the septa usually withdraw from the axis. Diphymorphic corallites are occasional. The dissepimentarium comprises one complete row of dissepiments or rarely a second incomplete one. The external wall is 0.5–0.8 mm thick and regular. Longitudinal section: The tabulae are almost always complete, upturned towards the columella, concave up in the periphery, forming a peripheral gutter. The dissepiments are small (0.2 mm large, 0.4–0.6 mm long), inclined at 75–80° towards the tabularium. There are 18–20 tabulae and 25–30 dissepiments per centimetre height.

Discussion. – All specimens fit perfectly with the definition of *S. pauciradiale*. One colony from the Topluca section (Fig. 3J) shows small-sized *S. asiaticum*-like corallites in its peripheral zone (see *S. asiaticum* and *S. irregulare* for comparison).

Occurrence. – *S. pauciradiale* is relatively common in the Warnantian of W Europe (Poty 1981) and N Africa (Aretz 2010) where it marks the base of the RC7 zone of Poty *et al.* (2006). The species occurs in the uppermost Viséan and Serpukhovian of SE China (Lin *et al.* 2012) and in the lower Warnantian of S Turkey (Anatolides: Denayer 2012). In NW Turkey, it is only known in the lower Warnantian RC7β coral biozone and MFZ14 foraminiferal biozone of Poty *et al.* (2006).

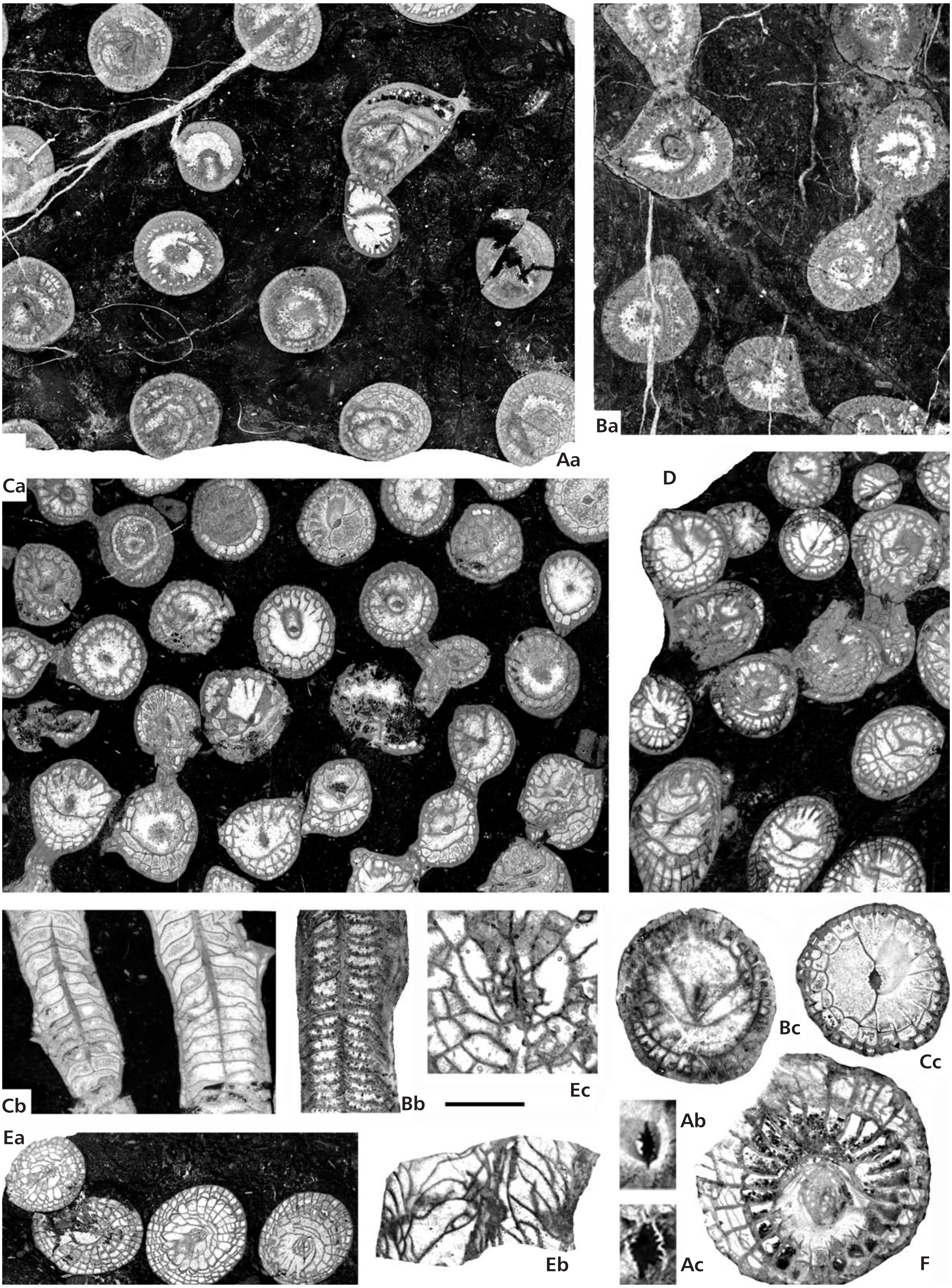
***Siphonodendron* sp. A**
Figure 5E, F

?1976 *Lithostrotion rossicum* Stuckenberg. – Onoprienko, p. 11, pl. 3, figs 1, 2.

Material. – Two fragments of colonies from the Gökgöl and Topluca sections.

Description. – Transverse section: Small-sized *Siphonodendron* with corallites 6 mm large (maximum 7 mm, Fig. 6) and 4.5 mm (maximum 6 mm) of tabularium diameter. There are 27 septa of both orders (maximum 29). The major septa are 3 mm long; the minor septa are 1–1.5 mm long. All the septa are thin and straight. The cardinal septum is longer and connected to the columella. The cardinal fossula is conspicuous. The axial plate is 1–1.2 mm long and bears 6–12 septal lamellae which are irregular, bifid and sometimes longer than the axial plate, producing a star-shaped columella (Fig. 5Ec, F). Some of the lamellae are confluent with the axial ends of the septa while others are withdrawn and have a sharp or rounded end. The dissepimentarium contains 4–5 rows of interseptal dissepiments, two of them are concentric, and the others are V-shaped or herringbone. The external wall is thin and straight. Longitudinal section: The tabulae are incomplete, steeply upturned towards the columella, tent- or bell-shaped in the axial part and declined towards the periphery. The dissepiments are small (less than 1 mm long and high) and inclined at 40–50° towards the tabularium. There are 16 tabulae and 20 dissepiments per centimetre height. The axial structure appears as an irregularly thick

Figure 5. A, B – *Siphonodendron rallii* sp. nov. (Warnantian–Late Viséan); A – specimen G.5.10 from Gökgöl, Aa: TS in a colony (× 3), Ab, Ac – close-up views of the columella, TS (× 10); B – G.16.6 (holotype) from Gökgöl, Ba – TS (× 3), Bb – LS (× 3), Bc – TS (× 6). • C, D – *Siphonodendron irregulare* (Phillips, 1836) (Warnantian–Late Viséan); C – K.12.1 from Kokaksu, Ca – TS (× 3), Cb – LS (× 3), Cc – TS (× 6); D – SR.7.15, TS (× 3). • E, F – *Siphonodendron* sp. A. (Moliniacian–Early Viséan); E – G.2.1 from Gökgöl, Ea – TS (× 3), Eb – LS (× 6), Ec – close-up view of the columella, TS (× 10); F – ET.4.2 from Topluca, TS (× 6). Scale bar equals 5 mm for A, Ba, Bb, Ca, Cb, D, Ea, 2.5 mm for Bc, Cc, Eb, F, 1.5 mm for Ab, Ac and Ec.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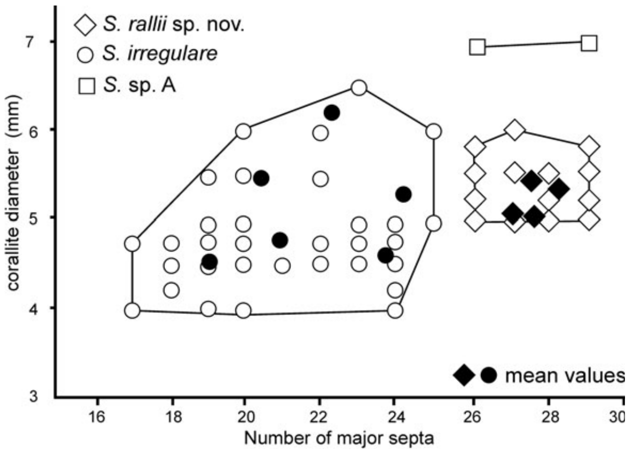


Figure 6. Scatter diagram showing the number of major septa plotted against corallite diameter for *Siphonodendron irregulare* (Phillips, 1836), *Siphonodendron rallii* sp. nov. and *Siphonodendron* sp. A, based on 56, 24 and 5 measurements, respectively. The mean values are given for each colony.

lath, irregularities being due to the irregular septal lamellae (Fig. 5Eb).

Discussion. – These small colonies belong to an as yet undescribed species sharing with *S. irregulare* (Phillips, 1836) and *S. intermedium* Poty, 1981, a similar diameter and number of septa. However *S*. sp. A differs from the latter by a wider dissepimentarium and withdrawn septa. The peculiar star-shaped axial structure is a specific character of large *Siphonodendron* species but not common in small-sized species. *S*. aff. *intermedium* from the Holkerain of Cumbria, figure by Poty (1993, figure 7:5) also shows a similar diameter but its septa are less numerous and longer than in the present species, however it shows occasionally a similar columella. Onoprienko (1976) described similar forms with short minor septa under the name *Lithostrotion rossicum* Stuckenberg 1904 in early Viséan strata of the Omolon Massif (E Siberia). As *S. rossicum* Stuckenberg 1904 has been synonymised with *S. pauciradiale* (McCoy, 1844) by Hill (1938–1941), this species should be renamed. Supplementary material from NW Turkey or Omolon is needed for an accurate description.

Occurrence. – *S.* sp. A is known in the lower Viséan in the Omolon, where it is accompagnied by *S. ondulosum* and *Palaeosmilia murchisoni*. The Turkish specimens are from time-equivalent strata dated as the upper Moliniacian by foraminifers (MFZ11B of Hance *et al*. 2011).

Siphonodendron irregulare **(Phillips, 1836)**
Figure 5C, D

*1836 *Lithodendron irregulare* Phillips; p. 202, pl. 2, figs 14, 15.

?1958 *Lithostrotion rossicum* Stuckenberg. – Dobroljubova, p. 151, pl. 21, figs 1–5.

?1958 *Lithostrotion volkovae* Dobroljubova; p. 153, pl. 22, figs 1, 2.

1960 *Lithostrotion irregulare* Phillips. – Vassiljuk, p. 83, pl. 21, figs 1–1c.

1966 *Lithostrotion irregulare* Phillips. – Bykova, p. 132, pl. 21, figs 1, 2.

1966 *Lithostrotion volkovae* Bykova; p. 134, pl. 21, figs 6, 7.

1977 *Lithostrotion* (*Siphonodendron*) *volkovae* Dobroljubova. – Khoa, p. 333, pl. 5, figs 3, 4.

non 1989 *Siphonodendron irregulare* (Phillips). – Wu & Zhao, p. 106, pl. 25, figs 2, 5.

2002 *Siphonodendron irregulare* (Phillips). – Aretz, p. 112, pl. 5, fig. 4, pl. 11, fig. 4. [*cum syn.*]

non 2002 *Siphonodendron* cf. *irregulare* (Phillips). – Aretz, p. 193, figs 6 1, 2.

2005 *Siphonodendron* sp. – Aretz & Nudds, p. 178, pl. 3, fig. 1.

2010 *Siphonodendron irregulare* (Phillips). – Aretz & Herbig, p. 302, fig. 6C.

2011 *Siphonodendron irregulare* (Phillips). – Denayer *et al*., p. 170, pl. 7, fig. N.

2012 *Siphonodendron irregulare* (Phillips). – Denayer, p. 324, fig. 7G.

Holotype. – Phillips' types are lost and no lectotype has been chosen (Poty 1981). Nevertheless, topotypes from Phillips' locality (Ashfell, Cumbria) were described and figured by Poty (1993).

Material. – 7 fragments of colonies: 2 from Gökgöl section, 3 from Kokaksu, 1 from Süzek and 1 from Topluca.

Diagnosis. – Dendroid to phaceloid *Siphonodendron*. Corallites with a mean diameter of 4.5–6 mm having 20–24 septa of both orders (maximum 26). Dissepimentarium comprising 1–4 rows of interseptal dissepiments. After Poty (1993).

Description. – Transverse section: The corallites have a mean diameter of 4.9 mm (maximum 7 mm, Fig. 6). The tabularium is 3.8–4 mm large. There are 19–21 septa of both orders (maximum 25 mm). The major septa are thin, except for the cardinal one, which is usually dilated and connected to the columella. The minor septa are restricted to the dissepimentarium but can extend into the tabularium. The columella varies from a 0.8–1 mm long axial plate to a spiny structure up to 1 mm thick. The dissepimentarium comprises one complete row of interseptal dissepiments, rarely a second incomplete one. In juvenile specimens, the dissepimentarium can be reduced or absent. Longitudinal section: The tabulae are complete, tent- or bell-shaped, upturned towards the columella and declined laterally, forming a shallow peripheral gutter. The dissepiments are small (0.2 mm long, 0.4 mm high) and almost vertically disposed. There are 14–18 tabulae and 30–32 dissepiments per centimetre height.

Discussion. – The dimensions and number of septa of the Turkish materials are those of *S. irregulare* (Phillips, 1836). The specimens have a similar narrow dissepimentarium. *S. irregulare* differs from *S. pauciradiale* by a larger diameter, greater number of septa and a narrower dissepimentarium. The species shares the dimensions of *S. rallii* sp. nov. but the latter has more septa.

Occurrence. – *S. irregulare* is known from the basal Livian to the upper Warnantian in Belgium and British Isles (Hill 1938–1941, Poty 1981, Aretz & Nudds 2005), in the upper Viséan of N Africa (Aretz 2010), SW Spain (Rodríguez *et al*. 2002) and S France (Aretz 2002). Its occurrence in NW China needs to be checked (Lin & Rodríguez 1993). In NW Turkey, *S. irregulare* occurs with *S. asiaticum* in the lower Warnantian (RC7β coral zone of Poty *et al*. 2006). The species is also present in the lower Warnantian in S Turkey (Anatolides: Denayer 2012).

Siphonodendron rallii **sp. nov.**
Figures 5A, B, 7A

Etymology. – This new species is dedicated to G. Ralli, pioneer in the study of the Carboniferous in Zonguldak and Bartın.

Holotype. – Colony G.16.6 – Zonguldak 2011 (3 TS, 1 LS).

Type horizon and locality. – Massive cherty limestone forming the upper unit of the Yılanlı Formation, Warnantian. Gökgöl section, 4 km SE of Zonguldak, NW Turkey.

Material. – 10 colonies: 4 from Kokaksu and 6 from Gökgöl.

Diagnosis. – *Siphonodendron* with corallites 5.5 mm in diameter and 27 septa of both orders. Tabularium wide, central area free of septa. Major septa short. Columella simple, usually thick and rarely connected to the septa. Tabulae complete, mesa-shaped with only axial ends upturned towards the columella.

Description. – Transverse section: The corallites have a mean diameter of 5.5 mm (maximum 6 mm, Fig. 6) with a wide tabularium reaching 5.2 mm in diameter. There are 27 septa of both orders on average (maximum 29). They are short, typically withdrawn towards the dissepimentarium, amplexoid in some cases. The minor septa are short. Both major and minor septa have an inflated base, with a cuneiform profile. The columella is 1.5 mm long, 0.3–0.4 mm wide and bears 5–10 short septal lamellae (Fig. 5Ab, c). The columella is rarely connected to the counter septum. The cardinal fossula is inconspicuous. The dissepimentarium comprises 1–2 rows of interseptal dissepiments, in rare cases, an incomplete third row appears. The external wall is thick (0.5–0.8 mm) and regular. Longitudinal section: The tabulae are complete, flat or mesa-shaped with only their axial parts upturned towards the columella (Fig. 5Bb). They are flat or mesa-shaped where the columella is absent. The dissepiments are 0.3 mm long and 0.8 mm high and inclined at 80° towards the tabularium. There are 12–18 tabulae and about 15 dissepiments per centimetre height.

Discussion. – The characters of these specimens do not fit with any described *Siphonodendron* species. Their size is equivalent to that of *S. irregulare* (Phillips, 1836) or *S. intermedium* (Poty, 1981) but they have a number of septa equivalent to *S. martini* (Milne-Edwards & Haime, 1851). The reduced length of the septa is usually not a specific character but in this material, all the specimens show short major and minor septa. The particularly flat or mesa-shaped tabulae with only their axial ends upturned towards the axis are uncommon in *Siphonodendron sensu stricto* but are usual within the N American "*Siphonodendron*". *Siphonodendron* with similar dimensions were figured – but not described – by Rodríguez & Falces (1992) from the upper Viséan of SW Spain. *Siphonodendron curvatum* (Yü, 1933) from SE China possesses the same number of septa but is quite larger and has longer septa. Corals attributed to *Lithostrotion curvatum* by Vassiljuk (1960) have similar dimensions but have also longer septa. *S. tindoufense* and *S. ouarkziense* Rodríguez & Somerville *in* Rodríguez *et al*., 2013 from the Lower Bashkirian of Morocco are both characterized by flat tabulae. *S. tindoufense* is smaller (3–5.5 mm) than *S. rallii. S. ouarkense* has similar dimensions and number of septa but its septa extend to the internal part of the tabularium. *S. nigmadnovi* (Ogar, 2008) from the Lower Viséan of Tien Shan show a similar tabularium and short septa but is characterized by a dissepimentarium commonly lacking. The strikingly short septa and wide tabularium of the Turkish materials are features commonly met in North American "*Siphonodendron*". "*S.*" *oculinum* Sando, 1963 shows such characters, together with similar diameter and number of septa (4.5–6 mm in diameter for 22–26 septa). The Turkish specimens share with the American corals a columella disconnected from the counter septum (less than 5% of the studied corallites show a long counter septum connected to the columella) and mesa-shaped tabulae. However, this new species differs from the American one by a more complex axial structure (thicker, bearing septal lamellae). If a likeness between the *S. rallii* and "*S.*" *oculinum* is clear, it has to be included in the genus *Siphonodendron sensu stricto* as its axial structure is typical of the Eurasian genus. Moreover, *S. rallii* corallites are very similar to some *S. martini* specimens having a narrow dissepimentarium and a simple columella. *S. rallii* has possibly evolved from *S. martini* by progenesis: the descendant (*S. rallii*) is smaller than its ancestor (*S. martini*), but its number of septa has almost not decreased while its morphological characters (dissepimentarium, columella) are simpler. The stratigraphic succession of the two species is compatible with this view. The observation of *S. martini* in anearly stage of development is necessary to confirm this interpretation.

Occurrence. – *S. rallii* is common in the massive cherty limestone of the Yılanlı Formation at Kokaksu and Gökgöl. Associated coral taxa are *S. scaleberense* and *S. asiaticum* indicating the RC7 and RC8 biozones while the foraminifers indicate the MFZ13–MFZ14 (Warnantian) zones of Poty *et al*. (2006). Up to now, *S. rallii* is not known outside the type area.

Siphonodendron martini **(Milne-Edwards & Haime, 1851)**
Figure 7B–D

*1851 *Lithostrotion martini* Milne-Edwards & Haime; p. 436.
?1958 *Lithostrotion caespitosum* Martin. – Dobroljubova, p. 155, pl. 22, fig. 3, pl. 23, figs 1–3.
p.p. 1960 *Lithostrotion caespitosum* Martin. – Vassiljuk, p. 85, pl. 21, fig. 3.
p.p. 1960 *Lithostrotion curvaturum* Yü. – Vassiljuk, pl. 21, figs 2, 2a.
1966 *Lithostrotion caespitosum* Martin. – Bykova, p. 135, pl. 21, figs 3, 4.
1975 *Siphonodendron fraiponti* Charles. – Poty, p. 78, pl. 2, figs 4, 5, pl. 3, figs 3–8.
2005 *Siphonodendron martini* (M.-E. & H.). – Aretz & Nudds, p. 178, pl. 3, fig. 2. [*cum syn.*]
2009 *Siphonodendron martini* (M.-E. & H.). – Rodríguez & Said, p. 10, pl. 1, figs 1, 2.
2010 *Siphonodendron martini* (M.-E. & H.). – Aretz, p. 334, fig. 5h.
2011 *Siphonodendron martini* (M.-E. & H.). – Aretz, p. 611, fig. 9E.
2011 *Siphonodendron martini* (M.-E. & H.). – Denayer *et al*., p. 171, pl. 6, fig. K.
2012 *Siphonodendron martini* (M.-E. & H.). – Somerville *et al*., p. 311, fig. 3B.
2013 *Siphonodendron martini* (M.-E. & H.). – Said *et al*., p. 375, fig. 6B.

Lectotype. – Chosen by Semenoff-Tian-Chansky & Nudds (1979): specimen E 1446, Lower Carboniferous, Yorkshire; Collection Phillips, University Museum of Oxford, figured by Milne-Edwards & Haime (1851).

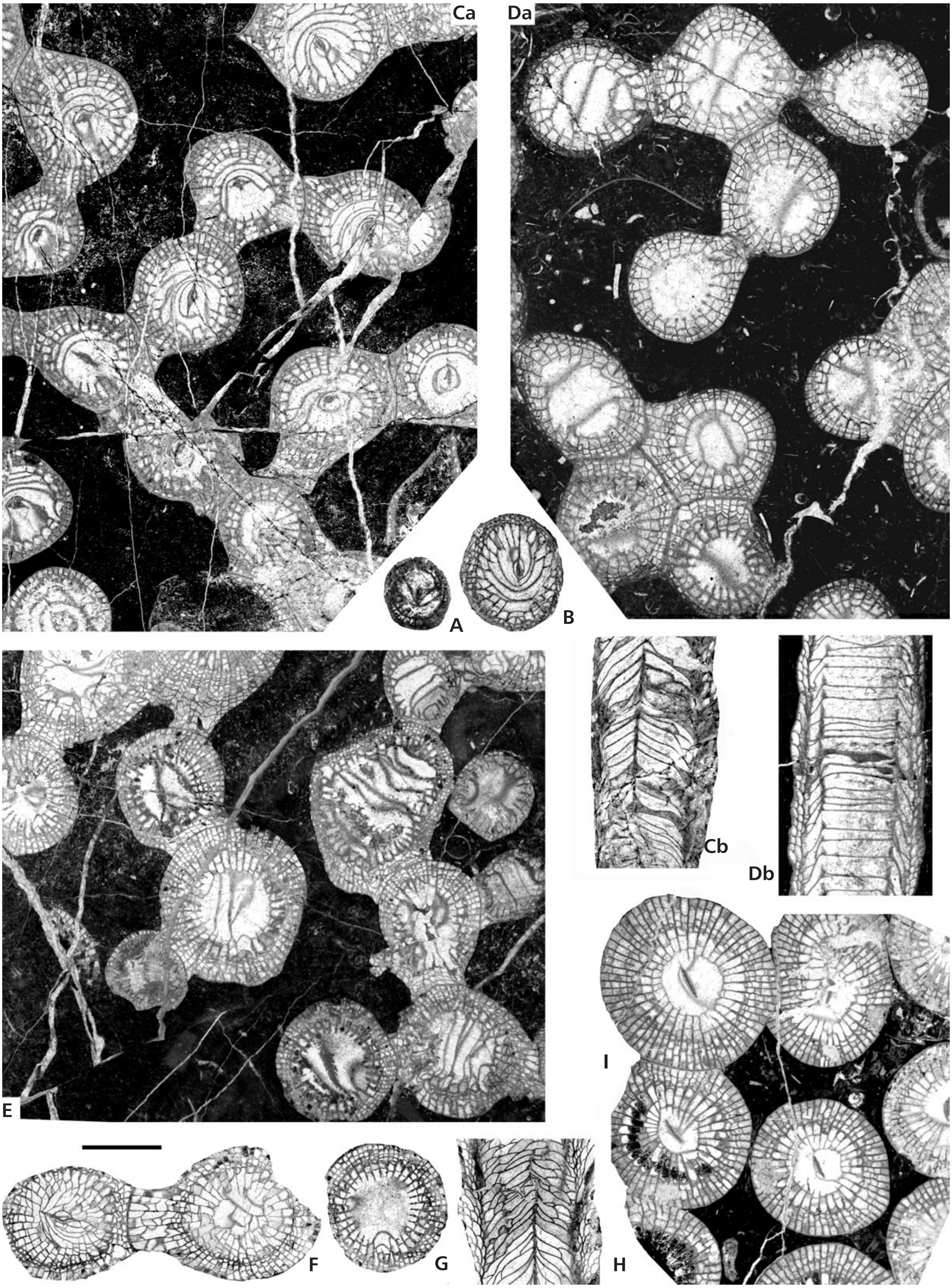
Material. – 19 colonies and fragments: 6 from the Kokaksu section, 3 from Gökgöl, 2 from Amasra (coll. Ralli), 3 from Topluca and 5 from Süzek.

Diagnosis. – Phaceloid *Siphonodendron* with corallites 6–10 mm in mean diameter, having 23–25 septa of both orders and 2–4 rows of interseptal dissepiments. After Semenoff-Tian-Chansky & Nudds (1979).

Description. – Transverse section: The corallites with a mean diameter of 7.3 mm (maximum 9 mm, Fig. 8). The tabularium is on average 6.3 mm in diameter. There are 25 septa of both orders (maximum 29). They are long (up to 1/3 of the corallite radius), straight and few of them reach the columella. The minor septa are half as long as the major and they enter slightly into the tabularium. The columella is 1.5–2 mm long, 0.3–0.4 mm thick and bears some rare septal lamellae. The cardinal fossula is inconspicuous except in some diphymorphic corallites (Fig. 7Da). The dissepimentarium comprises 2–3 – rarely 4 – rows of interseptal dissepiments. Some lonsdaleoid dissepiments occur in large-sized specimens with connecting processes. The external wall is 0.25 mm thick and regular. Longitudinal section: The tabulae are mainly complete but some declined peri-axial tabellae were noticed. In diphymorphic corallites, the tabulae are complete and mesa-shaped (Fig. 7Db). The dissepiments are 0.3 mm long and 0.7 mm high and declined towards the tabularium at an angle varying between 50° and 80°. There are 18–20 tabulae and 20–24 dissepiments per centimetre height.

Variability. – More than the dimensions and number of septa of the corallites, the variability affects the dissepimentarium width and the vertical continuity of the columella. Nevertheless, diphymorphic and columellate colonies are found in the

Figure 7. A – *Siphonodendron rallii* sp. nov., specimen G.16.6 (holotype) from Gökgöl, TS (× 3). • B–D – *Siphonodendron martini* (Milne-Edwards & Haime, 1851); B – G.15.1 from Gökgöl, TS (× 3); C – K.11.1 from Kokaksu, Ca: TS (× 3), Cb: LS (× 3); D – ET.2.4 from Topluca, Da – TS showing diphymorphic corallites (× 3), Db – LS (× 3). • E–H – *Siphonodendron scaleberense* Nudds & Somerville, 1987; E – KR.3.b.1 from Kokaksu (loose block), TS (× 3); F – G.2.5 from Gökgöl, TS (× 3); G –SR.6.30 from Süzek, TS (× 3); H – ET.3.6 from Süzek, LS (× 3). • I – *Siphonodendron kleffense* (Schindewolf, 1928), SR.6.2 from Süzek, TS (× 3). All the specimens are Warnantian (Late Viséan). Scale bar equals 5 mm for all.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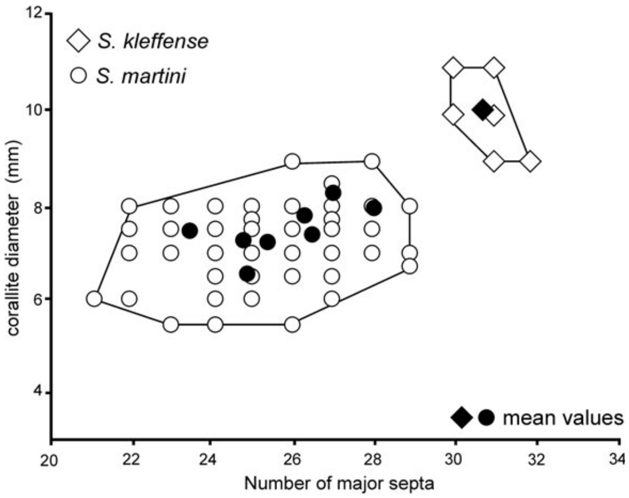


Figure 8. Scatter diagram showing the number of major septa plotted against corallite diameter for *Siphonodendron martini* (Milne-Edwards & Haime, 1851) and *Siphonodendron kleffense* (Schindewolf, 1928), based on 88 and 8 measurements, respectively. The mean values are given for each colony.

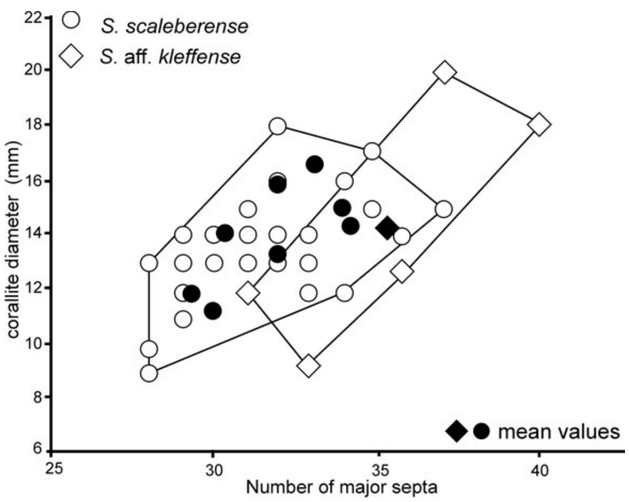


Figure 9. Scatter diagram showing the number of major septa plotted against corallite diameter for *Siphonodendron scaleberense* Nudds & Somerville, 1987 and *Siphonodendron* aff. *kleffense* (Schindewolf, 1928), based on 35 and 8 measurements respectively. The mean values are given for each colony.

same facies, even in the same beds. The origin of this variability is thus not only ecological or can be explained by temporary (seasonal?) changes in the local environment.

Discussion. – The Turkish specimens differ from the W European *S. martini* (Milne-Edwards & Haime, 1851) by a larger dissepimentarium, however this character should not be considered as sufficient to exclude them from the species. Indeed, colonies figured – among others – by Aretz & Herbig (2010) and Rodríguez *et al.* (2002) show commonly up to four rows of dissepiments. *S. martini* being a long-ranging species (from Moliniacian to Serpukhovian), its morphology can vary slightly. Varieties or stratigraphic and/or geographic subspecies could exist but they need to be documented.

Occurrence. – *S. martini* is probably the most common *Siphonodendron* species through the Viséan. It is known from the Moliniacian to the Warnantian in Belgium and British Isles (Poty 1981, 1984; Aretz & Nudds 2005), in the Warnantian and Serpukhovian of N Africa (Aretz 2010, 2011; Aretz & Herbig 2010; Rodríguez *et al*. 2013), SE China (Yü 1933, Lin *et al*. 2012), and in the Viséan–Serpukhovian of the Russian Platform (Dobroljubova 1958). In NW Turkey, *S. martini* is present in Zonguldak and Bartın area, in the Moliniacian and Warnantian substages.

***Siphonodendron scaleberense* Nudds & Somerville, 1987**
Figure 7E–H

1977 *Lithostrotion* (*Siphonodendron*) *affine* (Fleming). – Khoa, p. 336, pl. 4, figs 3a–d.
1985 *Siphonodendron* sp. B. – Semenoff-Tian-Chansky, pl. 13, fig. 5.
*1987 *Siphonodendron scaleberense* Nudds & Somerville; p. 295, figs 2a–f, 5a, b.
2002 *Siphonodendron scaleberense* Nudds & Somerville. – Rodríguez *et al*., p. 33, fig. 17.
2005 *Siphonodendron* cf. *scaleberense* Nudds & Somerville. – Aretz & Nudds, p. 180, pl. 3, figs 3–5.
2005 *Siphonodendron scaleberense* Nudds & Somerville. – Cózar *et al*., fig 12:5.
2010 *Siphonodendron scaleberense* Nudds & Somerville. – Aretz & Herbig, p. 302, fig. 6E.
2010 *Siphonodendron scaleberense* Nudds & Somerville. – Poty, p. 391, fig. 2G.
2011 *Siphonodendron scaleberense* Nudds & Somerville. – Denayer *et al*., p. 171, pl. 8, fig. N.

Holotype. – Specimen BM.R49898, Holkerian, Scaleber Quarry, Settle, North Yorkshire; British Museum of National History, London.

Material. – 19 colonies: 11 from Gökgöl section, 1 from Kokaksu, 4 from Topluca and 3 from Süzek.

Diagnosis. – Phaceloid *Siphonodendron* with large corallites (13–20 mm in diameter, 10–14 mm for the tabularium), having 30–41 septa of both orders and at least two rows of interseptal dissepiments. After Nudds & Somerville (1987).

Description. – Transverse section: The mean diameter of the corallites is 13.6 mm (maximum 18 mm, Fig. 9) while the mean tabularium diameter is 9–11 mm. There are on average 32 septa of both orders (maximum 40). The major ones are usually short and their length does not exceed the half of the corallite radius but in some case, they join the columella. They are thick, sinuous in the dissepimentarium but straight in the tabularium. The cardinal septum is shorter and positioned in a shallow fossula. The counter septum is usually connected to the columella. The minor septa are $^1/_4$–$^1/_3$ as long as the major but remain restricted to the dissepimentarium. They are often more sinuous than the major. The axial structure is composed of a long (up to 1/3 of the corallite radius in length) axial plate bearing some short septal lamellae. Diphymorphic corallites are occasional (Fig. 7:7). The dissepimentarium comprises 4–8 rows of concentric, V-shaped and herringbone interseptal dissepiments; the inner row is usually thicker. The external wall is regular and thin (0.2 mm). Longitudinal section: The tabulae are incomplete, the axial series of tabellae are cone-shaped and strongly upturn towards the columella while the periaxial tabellae are flat or concave, depressed towards the dissepimentarium. The dissepiments are 0.7–0.8 mm long and 1.5–2 mm high. They are inclined at 70–80° towards the tabularium but the inner row is almost vertical. There are 10–12 tabulae and 8–16 dissepiments per centimetre height.

Discussion. – The Turkish colonies fit in the definition of *S. scaleberense*. Their large size makes them easily distinguished from the other *Siphonodendron* species, except *S. ondulosum* Poty, 1981 and *S. sociale* (Phillips, 1836) sharing similar dimensions but differing from the latter by long minor septa and a conspicuous fossula.

Occurrence. – *S. scaleberense* is known from the base of the Warnantian in Belgium (guide of the RC7β biozone of Poty *et al*. 2006) and is also common in the Asbian of the British Isles (Nudds & Somerville 1987), SW Spain (Rodríguez *et al*. 2002) and N Africa (Aretz & Herbig 2010, Said *et al*. 2013). In NW Turkey, the species occurs with *S. asiaticum* in the Warnantian in Zonguldak and Bartın areas.

***Siphonodendron ondulosum* Poty, 1981**
Figures 10B–H, 12A–E

1933 *Lophophyllum fraiponti* Charles; p. 128, pl. 5, figs 26, 27. (*nomen oblitum*)
1933 *Lophophyllum asmaense* Charles; p. 82. (*nomem nudum*)
?1938 *Lithostrotion caswellense* Howel; p. 15, pl. 1, figs 23–26.
?1960 *Lithostrotion affine tanaicum* Vassiljuk; p. 86, pl. 22, fig. 1.
1984 *Lithostrotion martini* Milne-Edwards & Haime. – Somerville & Strank, p. 92, fig. 4h.
1975 *Siphonodendron martini* (Milne-Edwards & Haime). – Poty, p. 77, pl. 1, figs 1, 2, pl. 2, figs 1–3, pl. 3, figs 2, 9.
?1976 *Siphonodendron scoticum* (Hill). – Onoprienko, p. 12, pl. 2, figs 3–5.
?1976 *Siphonodendron proliferum* (Hall). – Onopirenko, p. 15, pl. 4, figs 5–7.
*1981 *Siphonodendron ondulosum* Poty; p. 26, pl. 8, figs 1–3. (*nomen protectum*)
?1982 *Siphonodendron* cf. *ondulosum* Poty. – Conil *et al*., pl. 5, fig. 6.
?1982 *Siphonodendron* aff. *ondulosum* Poty. – Conil *et al*., pl. 5, fig. 7.
1993 *Siphonodendron ondulosum* Poty. – Poty, p. 144, figs 7.1, 7.2.
1994 *Siphonodendron ondulosum* Poty. – Javaux, p. 130, figs 6.1–6.4.
2011 *Siphondendron ondulosum* Poty. – Denayer *et al*., p. 171, pl. 6, fig. J.

Holotype. – Colony 45, Neffe Formation, Moliniacian, Corphalie section, Meuse valley, Belgium; Collection Poty, Université de Liège, Belgium.

Remark. – *S. ondulosum* Poty, 1981 should have been considered as a junior synonyme of *S. fraiponti* (Charles 1933) following the Principle of Priority of the International Code of Zoological Nomenclature. The Code allows exception if the senior synonym has been unused (article 23.9.1 of the Code) and if the junior has been used at least in 25 publications by at least 10 authors during the last 50 years (article 23.9.2). The name *fraiponti* appears only in 5 publications since its creation by Charles in 1933 and for two of them, the name was misused [synonym of *S. martini* (Milne-Edwards & Haime, 1851) after Poty 1975b and Fedorowski & Bamber 2007] or was misinterpreted as *Lophophyllum* or *Koninckophyllum* (*e.g.* Fedorowski 1971). The junior name *ondulosum* appears in at least 20 publications covering only the last 30 years. Thus the conditions required to consider *fraiponti* as a *nomen oblitum* are not met. Nevertheless, the use of Charles' species leads to troubles because *S. fraiponti*'s holotype is not representative of the species (see below), is poorly preserved (silicified) and its description is inaccurate (*e.g.* contradictions exist between the text and plates). The case should be considered by the Commission of Zoological Nomenclature. Nevertheless, in order to preserve the nomenclatural stability, *S. ondulosum* Poty, 1981 should be maintained.

Material. – 20 colonies: 8 from the Süzek river section (Bartın), 1 from Topluca, 10 from Kokaksu and specimen IP-10861-02 of Charles' collection (Fig. 10Ba, b). The origin of this sample is imprecise: the thin section of

Lophophyllum fraiponti is labelled “Asma” (name of the hamlet downstream of Gökgöl section) but in the descriptive paragraph (Charles 1933, pp. 128–129), the author indicates Kokaksu as the origin of the specimen. Moreover, in his description of the Kokaksu section, Charles (1933, p. 82) reports *Lophophyllum asmaense* nov. sp. There is obviously confusion between the two localities and a mistake in the name given to the species.

Diagnosis. – *Siphonodendron* with corallites 8–9 mm large, having 25–28 septa of both orders (maximum 33). Two to six rows of regular interseptal dissepiments. Inner row thickened, forming a stereozone. External wall particularly undulating or arched. Tabulae conical, incomplete. After Poty (1981).

Description. – The colonies are phaceloid, dendroid or subcerioid (Figs 10E, Fd, 12D), up to 1 m wide and 50 cm high. Transverse section: The corallites have a mean diameter of 10 mm (maximum 14 mm, Fig. 11). The mean number of septa of both orders is 28 (maximum 34). The major septa are straight and long, reaching usually the axial structure and connect to it. The minor septa are short (1.5–2 mm) and restricted to the most external part of the dissepimentarium where they rarely cross the second row of dissepiments (Fig. 10Fc, G). They are occasionally disrupted by second order lonsdaleoid dissepiments. The cardinal septum is slightly shorter than the other septa. The counter septum is usually longer and connected to the columella (Fig. 12E). The columella is 2–2.5 mm long and bears rare short and thick septal lamellae. The axial structure is discontinuous vertically in some specimens. The dissepimentarium is made of 6–10 rows of interseptal dissepiments (concentric, angulo-concentric, V-shaped and herringbone, Fig. 10G), the inner rows are densely packed while the innermost is usually thickened and forms a stereozone. Second order lonsdaleoid dissepiments are not rare (Fig. 10Da, b). The external wall is thick (0.25–0.3 mm) and undulating or arched in fasciculate specimens but straight and festooned in subcerioid parts of the colonies (Fig. 12Ba, C, D). Longitudinal section: The tabulae are incomplete but not clearly separated in axial and periaxial series. The central ones are cone- or tent-shaped, upturned towards the axis and some lateral are flat or dome-shaped and interfingered with the others. The dissepiments are 2–4 mm long and 0.8–1 mm high, declined at 40–50° towards the tabularium. There are 16–20 tabulae and 18–20 dissepiments per centimetre height (Fig. 10C).

Discussion. – The Turkish colonies of *S. ondulosum* Poty, 1981 present several differences with the Belgian ones. 1) The corallites are slightly larger (10 mm on average versus 8 mm in Belgian material) and countain more septa (28–30 versus 25–28). 2) Some specimens show lonsdaleoid dissepiments, sometimes numerous and well developed. However, lonsdaleoid dissepiments – even not common – were documented in British specimens (Nudds 1993). 3) The subcerioid trend is frequently well marked in some Turkish colonies. Poty (1993) showed that the subcerioid trend occurs in high-energy environments. Indeed phaceloid and subcerioid are never observed in the same beds in Turkish sections. The first occurs in packstone together with fasciculate colonies of *Dorlodotia briarti,* while subcerioid *Siphonodendron* are frequent in grainstone and rudstone together with large colonies of *Dorlodotia euxinensis* also subcerioid. The specimen published as *Lophophyllum fraiponti* Charles, 1933 is a *S. ondulosum*, but the specimen presents a narrow dissepimentarium (3–4 rows) proportionaly to its diameter and its tabulae are particularly seldom divided. These features associated with the poor preservation (silicification) of the specimen as well as with the availability of one single corallite argue for dismissing it as a holotype.

Occurrence. – *S. ondulosum* Poty, 1981 has been described in the Moliniacian of Belgium (Poty 1981, 1984, 1993), in England (Javaux 1994), and possibly in the Omolon Massif (Conil *et al.* 1982). In NW Turkey the species is abundant in the Kokaksu (Zonguldak) and Süzek section (Bartın), in association with *Dorlodotia briarti*, *D. euxinensis*, *Ceriodotia bartinensis*, *Clisiophyllum multiseptatum* and *Palaeosmilia murchisoni*. Subcerioid forms are mainly found in the Kokaksu section, in a level slightly younger than beds yielding fasciculate colonies. Foraminifers from both levels indicate the upper Moliniacian (MFZ11-B).

***Siphonodendron kleffense* (Schindewolf, 1928)**
Figure 7I

1928 *Siphonodendron* (*Cystidendron*) *kleffense* Schindewolf; p. 149, tab. 2.
*2000 *Siphonodendron kleffense* (Schindewolf). – Weyer, pl. 2, fig. 4a, b.
?2002 *Siphonodendron* aff. *martini* (M.-E. & H.). – Rodríguez *et al*., p. 34, fig. 18.
2011 *Siphonodendron kleffense* (Schindewolf). – Denayer *et al*., p. 170, pl. 8, fig. O, P.
2013 *Siphonodendron* gr. *kleffense* (Schindewolf). – Aretz *et al*., p. 92, fig. 4E.

Lectotype. – Schindewolf (1928) did not designte any holotype, described very superficially the specimen and figured only a very schematic longitudinal section of his new subgenus *Cystidendron* of which *C. kleffense* is the type species. The species is consequently a *nomen nudum*. However, Weyer (2000) figured one of Schindewolf’s specimens (No. X10226) as the lectotype of the species which he

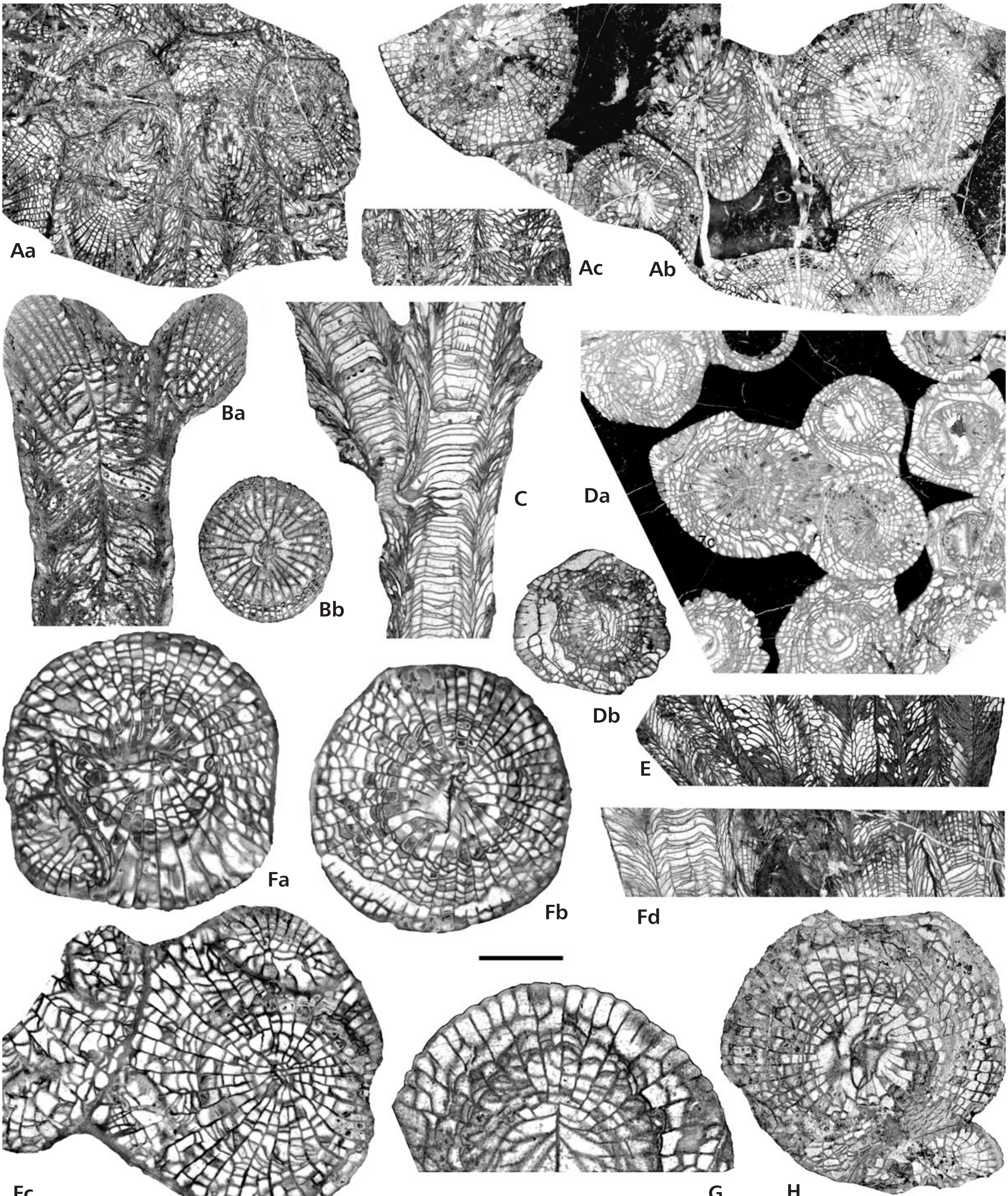


Figure 10. A – *Siphonodendron* aff. *kleffense* (Schindewolf, 1928) (Warnantian–Late Viséan), specimen IP-15123-01 from Kokaksu (coll. Charles), Aa, Ab – successive TS (× 2), Ac – LS (× 2). • B–H – *Siphonodendron ondulosum* Poty, 1981 (Moliniacian–Early Viséan); B – IP-10861-02 (type of *Lophophyllum fraiponti* Charles, 1933) from Kokaksu (?), Ba – LS (× 2), Bb – TS (× 2); C – SR.4.9 from Süzek, LS (× 2); D – K.4.10 from Kokaksu showing lonsdaleoid dissepiments, Da, Db – successives TS (× 2); E – SR.5.24 from Süzek showing a subcerioid trend, LS (× 2); F – SR.5.6 from Süzek, Fa–c – offsetting corallites, TS (× 4), Fd – LS (× 2); G – K.4.5, close view of the dissepimentarium and short minor septa, TS (× 4); H – K.7.5, one of the larges corallite observed, TS (× 3). Scale bar equals 7.5 mm for A–E, Fd, 5 mm for H and equals 3.75 mm for Fa–c, G.

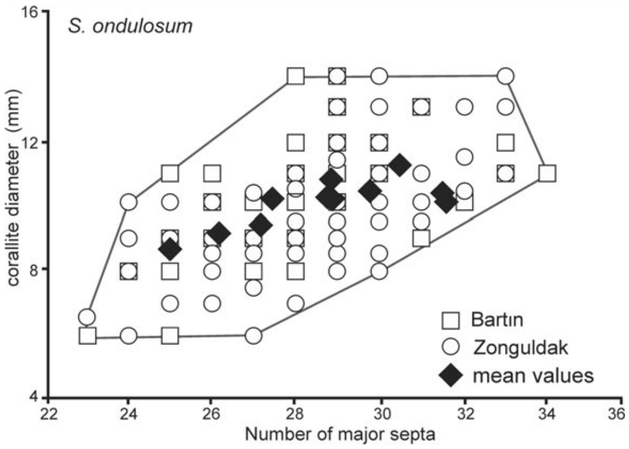


Figure 11. Scatter diagram showing the number of major septa plotted against corallite diameter for *Siphonodendron ondulosum* Poty, 1981, based on 140 measurements. The mean values are given for each colony.

transferred to the genus *Siphonodendron* McCoy, 1849. *S. kleffense* has not been revised yet but the diagnosis published in Denayer *et al*. (2011) – based on Schindewolf's material and newly collected specimen from the Visé area – acts as an emended definition.

Material. – One small fragment of a colony from the Süzek section.

Diagnosis. – Dendroid to subcerioid colonies with large corallites (7–12 mm in diameter, 4–8 mm for the tabularium) having 28–32 septa of both orders. Major septa long, sinuous in the dissepimentarium, straight in the tabularium, often connected to the columella. Dissepimentarium comprising 4–6 rows of interseptal dissepiments, inner row thickened. Tabulae incomplete: axial tabellae upturned towards the columella, periaxial tabellae declined towards the dissepimentarium. After Denayer *et al*. (2011).

Description. – Transverse section: The mature corallites have a mean diameter of 10 mm (maximum 11 mm, Fig. 8) and 30–32 septa of both orders. The major septa are long and reach the axis. They are straight in the tabularium, thin or slightly thickened in their middle part. The minor septa are half as long as the major but never cross the inner edge of the dissepimentarium. The cardinal septum is usually a bit shorter than the others and often more tortuous. The counter septum is thinner and longer than the other septa and is commonly connected to the columella. Some corallites show slightly shorter alar septa. The columella is a long (1.5–2.5 mm) and thin (0.3–0.6 mm) styliform plate devoid of septal lamellae. The cardinal fossula is shallow and marked by the withdrawal of the cardinal septum and the dissepimentarium. The dissepimentarium is composed of 4–5 rows of concentric or herringbone (in large corallites) interseptal dissepiments. The inner row is thickened and forms a stereozone. The external wall is regular and thick (0.4 mm).

Discussion. – With 28–32 major septa and 7–8 mm diameter, *S. kleffense* (Schindewolf, 1928) can easily be distinguished from *S. martini* (Milne-Edwards & Haime, 1851) (23–25 septa for a similar diameter) and from *S. ondulosum* Poty, 1981 (25–28 septa, 9–10 mm diameter). *S. scaleberense* Nudds & Somerville, 1987 and *S. sociale* (Phillips, 1836) are both larger and have a lower ratio of number of septa to diameter. Specimens attributed to *S.* aff. *martini* from the upper Viséan of SW Spain by Rodríguez *et al.* (2002) is questionably *S. kleffense* sharing with this species similar dimensions and number of septa but showing a simpler tabularium.

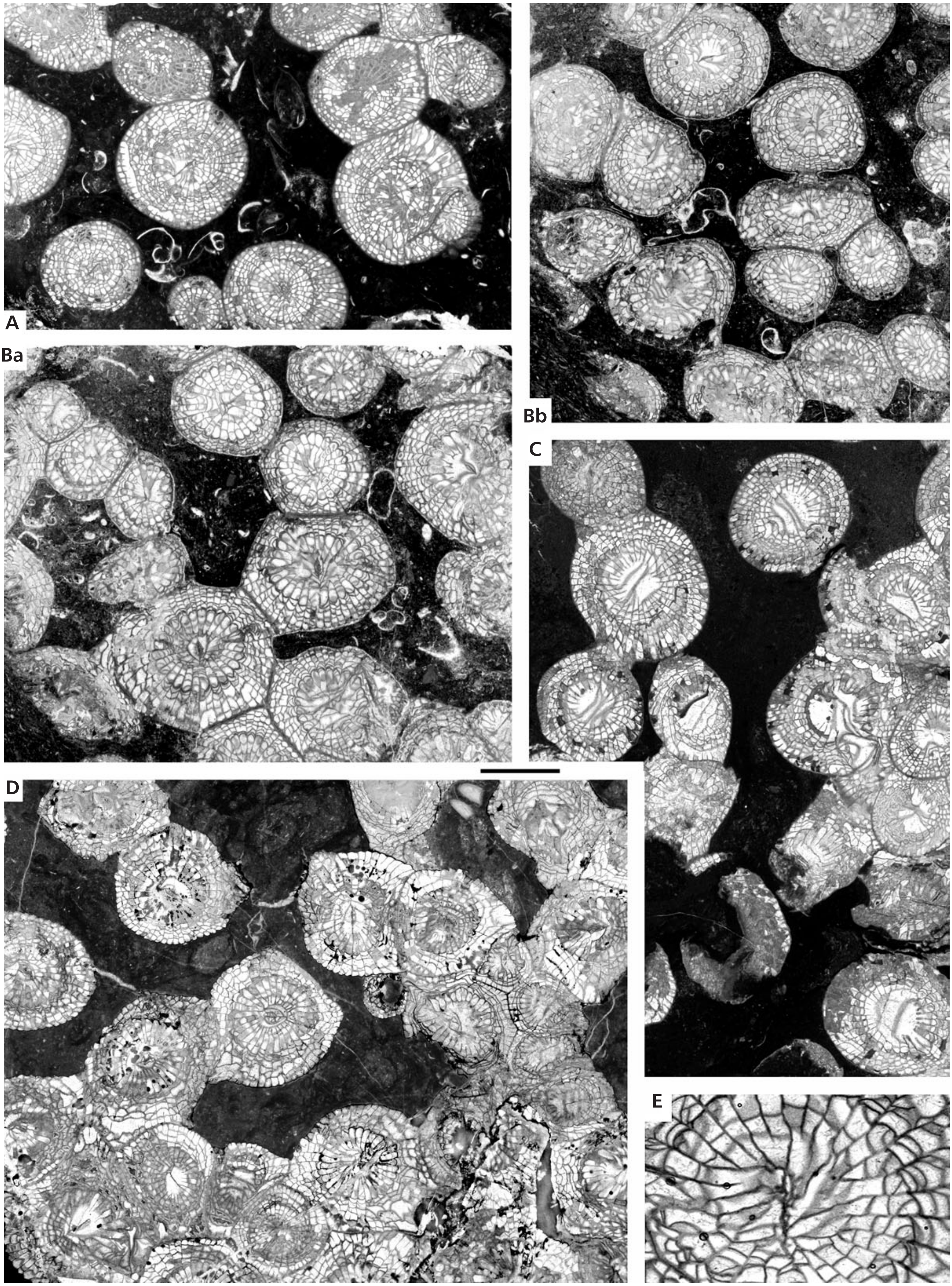
Occurrence. – The species is known in the lower Warnantian (RC7 biozone of Poty *et al.* 2006) in the Visé area and Campine Basin (NE Belgium, Poty, pers. com.) and W Germany (Weyer 2000). It has recently been signalled in the Moroccan Tafilalt (Aretz *et al.* 2013). In Turkey, *S. kleffense* was found with *S. asiaticum* and *S. scaleberense* in the upper part (lower Warnantian) of the Süzek section (Bartın).

***Siphonodendron* aff. *kleffense* (Schindewolf, 1928)**
Figure 10Aa–c

Material. – 3 colonies: one belonging to Charles' collection (not figured in his 1933 publication), coming from the Kokaksu section; the others come from the Kokaksu and Kisla sections.

Description. – These colonies show a strong subcerioid trend, corallites being either cylindrical and isolated or prismatic in the same colony. The corallites in cerioid zones are usually smaller and have less septa than in the fasciculate ones (Fig. 10Aa). Transverse section: The corallites have a mean diameter of 13.8 mm (maximum 20 mm, Fig. 9) with a tabularium measuring 8.5 mm on average (maximum 11 mm) and have 31–40 septa of both orders. The major septa are long and straight in the dissepimentarium, wheras they are slightly curved in the tabularium.

Figure 12. A–E – *Siphonodendron ondulosum* Poty, 1981 (Moliniacian–Early Viséan). • A – specimen SR.5.6 from Süzek, TS (× 2); Ba, Bb – SR.5.4 from Süzek, successive TS (× 2); C – SR.4.9 from Süzek showing diphymorphic corallites, TS (× 2); D – K.4.5 from Kokaksu, TS (× 2); E – SR.5.24 from Süzek, close view of the columella, TS (× 6). Scale bars equals 7.5 mm for A–D and 2.5 mm for E.


A
Ba
Bb
C
D
E

The minor septa are long and enter into the tabularium but are thinner than the major ones. The axial structure is made of a thin columella, usually poorly defined and with numerous septal lamellae. The dissepimentarium comprises 4–7 rows of concentric and V-shaped interseptal dissepiments, the two inner rows being usually herringbone. The external wall is regular and thin. Longitudinal section: The tabulae are incomplete but not separated in axial and periaxial series, dome- or cone-shaped and declined towards the periphery. The dissepiments are small (1–1.5 mm long and high). There are 15–17 tabulae and 15 dissepiments per centimetre height.

Discussion. – The large dimensions of the corallites and the high number of septa compare to *S. scaleberense* Nudds & Somerville, 1987 and *S. sociale* (Phillips, 1836) but the subcerioid trend is unknown in these species. Contrarily, *S. kleffense* (Schindewolf, 1928) show commonly a cerioid habitus but its dimensions are generally smaller. The present specimen possibly belongs to a new species but the material is unfortunately not sufficient for accurate description and comparison.

Occurrence. – *S.* aff. *kleffense* occurs in the Warnantian (foraminifers indicate the MFZ14 biozone) of Kokaksu and Kisla sections. Subcerioid *S. kleffense* are known in time-equivalent levels in Visé area and Campine Basin (E. Poty, pers.comm.).

Genus *Lithostrotion* Fleming, 1828

Type species. – *Lithostrotion striatum* Fleming, 1828, synonym of *Lithostrotion vorticale* (Parkinson, 1808), Viséan, England, Fleming's holotype being lost (Kato 1971).

Diagnosis. – Coral forming cerioid colonies with prismatic corallites presenting a calicular platform surrounding a central depression occupied by the axial structure. Major septa long, reaching the axis. Minor septa short, restricted to the dissepimentarium or entering slightly into the tabularium. Axial structure made of an axial plate bearing septal lamellae. Numerous interseptal dissepiments, seldom transeptal dissepiments. Tabularium narrow. Tabulae usually incomplete. Axial tabellae conical. Periaxial tabellae flat, subhorizontal or declined towards the periphery. Lateral, intermural and non-parricidal increase. After Poty (1981).

Discussion. – Often confused with *Siphonodendron* in the older literature, the name *Lithostrotion* must be retained for the cerioid forms of lithostrotionid corals as suggested by Schindewolf (1928), Hill (1934), Poty (1975a) and Nudds & Somerville (1987). Scrutton (1983) documented ducts crossing the wall between corallites in cerioid forms but not in fasciculate ones. Nevertheless, such ducts are commonly observed in *Siphonodendron* where they connect the offsets to the mother corallite, at least during the first stages of development (see Fig. 10C). This connection constitutes the first step of the integration process leading to highly integrated colonies within the plocoid forms of lithostrotionids (*Orionastraea* Smith, 1916 and *Pleionastraea* Nudds, 1999) but is not a generic character. In shallow water high-energy environment, *S. ondulosum* Poty, 1981 tends to acquire a subcerioid habitus that leads, after Poty (1993) to the appearance of *L. araneum* (McCoy, 1844) by paedomorphosis in the Livian. This author identified a neotenic process in the separation of the offsets from its parent corallite, so delayed that the two corallites stay permanently joined and connected (Poty 1993, 2010). The discovery of *Lithostrotion potii* sp. nov. (see below) in the upper Moliniacian of Bartın does not cast doubt on Poty's phyletic model but modified the actors. *L. potii* originates probably in large sized-corallite subcerioid colonies of *S. ondulosum* through the same evolutionary process highlighted by Poty (1993). *L. potii* is the oldest species of the genus and probably gave rise to *L. araneum* in the uppermost Moliniacian or lowermost Livian through a reduction in size and number of septa. Poty (1984, 1993) documented in the Viséan of W Europe a heterochronic lineage *L. araneum – vorticale – decipiens – maccoyanum* characterized by a progressive decrease of size of the corallites governed by progenesis.

Lithostrotion potii sp. nov.

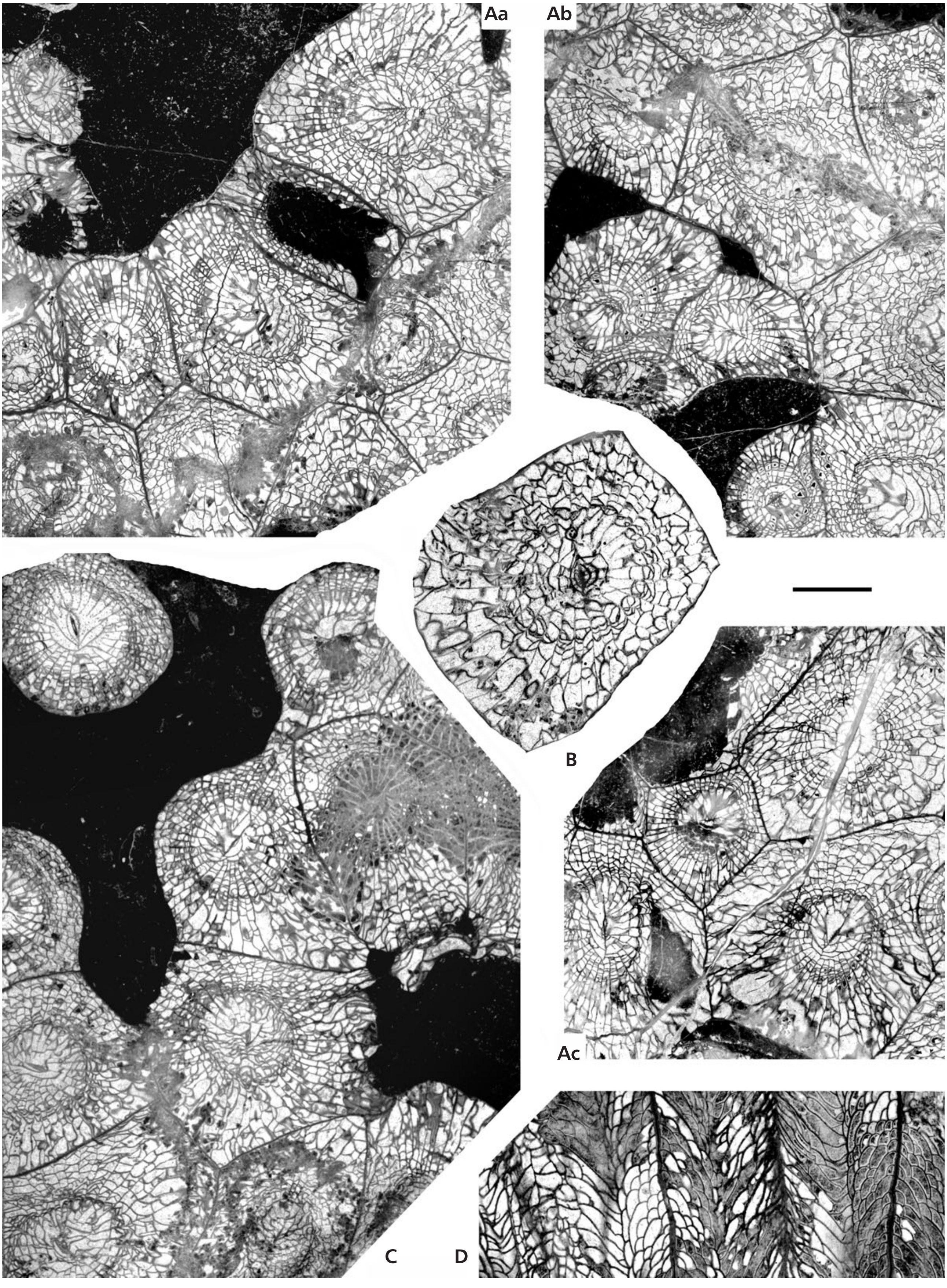
Figures 13, 14A–D

Etymology. – This oldest *Lithostrotion* species is dedicated to Prof. E. Poty for his work on Carboniferous rugose corals.

Holotype. – Colony SR.5.21/ Bartın/2011.

Type horizon and locality. – Unit SR5: light grey massive limestone with *Ceriodotia*. Foraminifers indicate the MFZ11B zone of Hance *et al.* (2011), *i.e.* the uppermost Moliniacian. Süzek section, 3 km NE of Bartın, NW Turkey.

Figure 13. A–D – *Lithostrotion potii* sp. nov. (Moliniacian–Early Viséan). A – specimen SR.5.18 (holotype) from Süzek, Aa–c – successive TS (× 2); B – SR.5.8 from Süzek, TS (× 3); C – SR.5.21 from Süzek, TS (× 2); D – SR.5.13 from Süzek, LS (× 2). Scale bar equals 7.5 mm for A, C, D and 5 mm for B.


Aa
Ab
B
Ac
C
D

Diagnosis. – *Lithostrotion* with large-sized corallites (15–20 mm, 8–10 mm for the tabularium) having 26–28 septa of both orders. Major septa long and thin. Minor septa variable in length, entering into the tabularium or withdrawn towards the periphery of the dissepimentarium. Dissepimentarium wide, composed of 10 or more rows of dissepiments.

Material. – Five colonies including the holotype (10 TS, 3 LS) from Süzek section.

Description. – Colonies are 10 cm high and up to 20 cm wide. They are cerioid but show occasionally subcerioid corallites in the periphery. Transverse section: The mature corallites are 10–20 mm large (maximum 22 mm) with a mean tabularium diameter of 8 mm (maximum 11 mm, Fig. 15) and have 26–28 septa of both orders (maximum 36, Fig. 15). The major septa are thin or slightly thickened in the tabularium where they are straight. They can be sinuous in the dissepimentarium; their axial ends are sharp. The length of the minor septa is variable. They can be reduced to short septal crests on the outer wall or extend up to the tabularium (Figs 13B, 14Cc). They are thin tortuous and discontinuous in the peripheral part of the dissepimentarium. Both cardinal and counter septa are long and connected to the columella (Fig. 14Ba). The cardinal fossula is shallow and marked by a withdrawal of the dissepimentarium. The columella is long, thin and sinuous. Some septal lamellae can occur and are confluent with the axial ends of some major septa (Fig. 14Ba, b). Rare diphymorphic corallites were observed. The dissepimentarium is wide and comprises 10–13 rows of dissepiments: concentric interseptal dissepiments in the outer part, angulo-concentric and V-shaped in the middle part and herringbone in the inner part of the dissepimentarium. The 3 or 4 inner rows are densely packed but not thickened. First and second order lonsdaleoid dissepiments occur in the largest corallites, some of them being naotic. The external wall is regular, 0.2–0.3 mm thick but can be thicker and undulating in corallites situated in the periphery of the colonies. Longitudinal section: The tabulae are incomplete, with the axial series interfingered into the periaxial series of tabellae. The axial tabulae are cone- or tent-shaped, strongly upturned towards the axis and can be tangential to the columella in places. The periaxial tabellae are dome- or bell-shaped or concave upside and declined towards the dissepimentarium. A peripheral gutter occurs in some specimens (Fig. 13D). The dissepiments are long but narrow, subvertical in the inner part of the dissepimentarium, larger and less declined in the periphery. The outer row (naotic) is almost vertically disposed. There are 20 tabulae and 18–20 dissepiments per centimetre height.

Variability. – The intra-specific variability affects particularly the length of the minor septa and the development of the columella. As stated before, in the periphery of colonies, some corallites are cylindrical and show a subcerioid trend (Fig. 13C). It is obviously an ecological phenomenon (different growth condition for different location of corallites in the colony) but these cylindrical corallites are very similar to the large sized-corallites of *S. ondulosum* observed in the underlying beds, which argues for a phyletic relationship between the two species.

Increase. – The smallest observed offsets are 3.5–4 mm large and comprise about 20 short and tortuous septa. Fragments of a thick wall rapidly develop between the offset and its parent. Irregular dissepiments – including lonsdaleoid – appear rapidly, before the wall is fully developed (Fig. 14Ca, b). The columella is the last element to form while the corallite tabularium is about 5 mm large. It stays connected to both the cardinal and counter septa.

Discussion. – The large dimensions (including the dissepimentarium width) and the higher number of septa allow an easy discrimination of *L. potii* sp. nov. and *L. araneum* (McCoy, 1844). The largest corallites of *L. araneum* however may have a high number of septa (up to 32, Poty 1981), overlapping the variability of *L. potii*. Moreover, the minor septa, even if very variable in length, are often entering into the tabularium while they are most commonly restricted to the dissepimentarium in *L. araneum*. The dissepimentarium is also larger in the new species and does not include any thicker row as commonly observed in *L. araneum*. Smal-sized corallites, corresponding to immature stages, are very similar to the mature corallites of *L. araneum*: equivalent diameter and number of septa, short minor septa and narrow dissepimentarium. These similarities, together with the stratigraphic distribution of the two species suggest close relationship between *L. potii* and *L. araneum* and probably a phyletic lineage. The Livian species appears probably through a reduction of size and a simplification of the dissepimentarium. *L. potii* shares with large corallites of *S. ondulosum* a similar tabularium diameter (8–11 mm for the first, 9–11 mm for the second), a similar size (15–19 mm for cylindrical corallites of *L. potii* and 14–18 mm for *S. ondulosum* corallites) and number of septa (26–36 for *L. potii*, 28–34 for *S. ondulosum*). They both show occasional transeptal dissepiments.

Occurrence. – *Lithostrotion potii* sp. nov. is the oldest species of the genus, known only in the *Ceriodotia* beds of NW Turkey. The foraminifers (primitive *Pojarkovella*) indicate the uppermost Moliniacian MFZ11B zone of Hance *et al.* (2011).

***Lithostrotion araneum* (McCoy, 1884)**
Figure 14Ea–c

*1844 *Astrea aranea* McCoy; p. 187, pl. 17, fig. 6.
?1958 *Lithostrotion basaltiforme* Phillips. – Dobroljubova, p. 178, pl. 28, fig. 2.
1981 *Lithostrotion araneum* (McCoy). – Poty, p. 20, pl. 4, figs 1–4. [*cum syn.*]
1983 *Lithostrotion araneum* (McCoy). – Scrutton, fig. 9.
1993 *Lithostrotion araneum* (McCoy). – Poty, fig. 7.3.
1994 *Lithostrotion araneum* (McCoy). – Poty & Hannay, p. 63, pl. 4, fig. 1.
?2003 *Lithostrotion basaltiforme* Phillips. – Fan *et al.*, p. 320, pl. 39, figs 4, 5.
2005 *Lithostrotion araneum* (McCoy). – Cózar *et al.*, fig. 12:4.
2010 *Lithostrotion araneum* (McCoy). – Aretz, p. 331, fig. 5c. [*cum syn.*]
2011 *Lithostrotion araneum* (McCoy). – Denayer *et al.*, p. 171, pl. 7, fig. M.
2012 *Lithostrotion araneum* (McCoy). – Denayer, p. 322, fig. 7D.

Holotype. – Specimen 50-1926, unknown origin; National Museum of Ireland, Dublin. Specimen F7467/1–3 is a syntype after Mitchell (1989).

Material. – 2 colonies from Gökgöl (Zonguldak).

Diagnosis. – *Lithostrotion* with corallites 12–18 mm large with a mean tabularium diameter of 4.5–5.5 mm, having 23–26 septa of both orders. Dissepimentarium wide, made of concentric, V-shaped and herringbone interseptal dissepiments. After Poty (1981, 1993).

Description. – The corallites are polygonal, 9–12 mm large (maximum 15 mm, Fig. 15). The mean tabularium diameter is 5.5 mm (maximum 7 mm). There are 21–24 septa of both orders (maximum 26). The major septa are long and several reach the axis. The cardinal septum is slightly shorter. The counter septum is usually longer and connected to the columella. The minor septa are 1/3–1/2 as long as the major and restricted to the dissepimentarium. The columella is 1.5–2 mm long, is often thickened and bears rare short septal lamellae (Fig. 14Ec). The dissepimentarium is composed of 7–12 rows of concentric, V-shaped and herringbone interseptal dissepiments. The inner row is thickened and forms a stereozone (Fig. 14Ea, b). The external wall is 0.25 mm thick and regular.

Discussion. – Except for a slightly narrower dissepimentarium, the Turkish specimens are identical to *L. araneum* from Belgium and the British Isles (Poty 1981). *L. araneum* is smaller than *L. potii* but larger than the other species of the genus (*L. vorticale*, *L. decipiens* and *L. maccoyanum*).

Occurrence. – *L. araneum* was considered as the oldest species of the genus and still is in W Europe. It is the guide taxa for the Livian RC6 coral biozone of Poty *et al.* (2006) but is also present is the Warnantian RC7 biozone. The species is present in Belgium, N France (Poty & Hannay 1994), British Isles (Mitchell 1989), SW Spain (Rodríguez *et al.* 2002), Morocco (Said *et al.* 2007, Aretz 2010) and Algerian Sahara (Semenoff-Tian-Chansky 1985). Similar forms were described in the Kuznetsk Basin (Dobroljubova 1958) and S China (Fan *et al.* 2003). *L. araneum* has been documented in the central Anatolides (Kongul Yayla: Denayer 2012). In NW Turkey, *L. araneum* occurs together with *Siphonodendron asiaticum* and *S. scaleberense* (RC7β subzone) in the base of the Warnantian stratified cherty limestone of the Gökgöl section.

***Lithostrotion vorticale* (Parkinson, 1808)**
Figure 16A

*1808 *Madrepora vorticalis* Parkinson; p. 45, pl. 5, figs 3, 6.
1981 *Lithostrotion vorticale* (Parkinson). – Poty, p. 22, pl. 5, figs 1–4. [*cum syn.*]
1983 *Lithostrotion vorticale* (Parkinson). – Scrutton, p. 137, fig. 10.
1985 *Lithostrotion decipiens* (McCoy). – S.-T.-C., pl. 14, fig. 1.
?1990 *Lithostrotion pelhatae* Vuillemin; p. 86, pl. 20, fig. 1.
?1993 *Lithostrotion vorticale* (Parkinson). – Lin & Rodríguez, p. 24, pl. 2, figs 2a, b.
2005 *Lithostrotion vorticale* (Parkinson). – Aretz & Nudds, p. 175, pl. 2, fig. 8. [*cum syn.*]
2005 *Lithostrotion vorticale* (Parkinson). – Cózar *et al.*, fig. 12.3.
2010 *Lithostrotion vorticale* (Parkinson). – Aretz & Herbig, p. 300, fig. 6A.
2011 *Lithostrotion vorticale* (Parkinson). – Aretz, p. 610, figs 9, 10.
2011 *Lithostrotion vorticale* (Parkinson). – Denayer *et al.*, p. 171, pl. 8, fig. J.
2012 *Lithostrotion vorticale* (Parkinson). – Somerville *et al.*, p. 311, fig. 3C.
2013 *Lithostrotion vorticale* (Parkinson). – Said *et al.*, p. 374, fig. 5I.

Holotype. – Parkinson's holotype is lost and no lectotype has been designated yet (Semenoff-Tian-Chansky & Nudds 1979).

Diagnosis. – *Lithostrotion* with medium-sized corallites having a mean tabularium diameter of 3.3–4.1 mm and

20–24 septa of both orders. Dissepimentarium made of concentric, V-shaped and herringbone interseptal dissepiments. After Poty (1981, 1993).

Material. – Three fragments of small colonies from the uppermost part of the Kokaksu section (Zonguldak).

Description. – Small colonies counting 4–8 prismatic corallites. Transverse section: The mean tabularium diameter is 4.7 mm (maximum 6 mm). There are 20–22 septa of both orders (maximum 24, Fig. 17). The major septa are long, extending almost to the axis, some of them are connected to the columella, including the cardinal and counter septa. The minor septa are half as long as the major but enter into the tabularium. The columella is 1–2 mm long and 0.4–0.6 mm thick. The dissepimentarium is composed of 3–4 rows of small concentric interseptal dissepiments. The external wall is thin and regular.

Discussion. – These colonies show all the morphologic features and size of the species *L. vorticale*. They can be easily discriminated from the other species by their dimensions (*L. decipiens* and *L. maccoyanum* are smaller, *L. araneum* and *L. potii* are both larger).

Occurrence. – *L. vorticale* occurs in the Livian and Warnantian of Belgium (Poty 1981) and the British Isles (Mitchell 1989), in the Warnantian of SW Spain (Rodríguez *et al*. 2002), in the Algerian Sahara (Semenoff-Tian-Chansky 1985) and Morocco (Aretz 2010, Rodríguez *et al*. 2012). In NW Turkey, the species is known in the silicified limestone forming the top of the Yılanlı Formation in the Kokaksu section. The foraminifers indicate the MFZ14 zone (top of the lower Warnantian, *i.e*. Asbian) but the entry of *Palastraea konincki* (Charles, 1933) a couple of metres below indicates the late Warnantian (*i.e*. Brigantian).

***Lithostrotion* sp.**
Figure 16Ba–c

Material. – One small colony from Kokaksu.

Description. – The corallites are prismatic and 12–18 mm large. The mean tabularium diameter is 7.5 mm (maximum 9 mm, Fig. 17). They have 27 septa of both orders on average (maximum 31). Major septa are long but do not reach the axis, except the counter septum, which is connected to the columella. The minor septa are half as long as the major and enter in the tabularium for more than1 mm. The columella is 3–5 mm long. There are 6–9 rows of concentric and V-shaped interseptal dissepiments. The inner row is slightly thickened. The external wall is thin (0.2 mm) and regular. The tabulae are dome-shaped. The dissepiments are declined towards the tabularium at 45° (Fig. 16Bc).

Discussion. – This colony is obviously a *Lithostrotion* and is quite similar to *L. araneum* but differs from the latter by its larger corallites: the smallest observed corallite has a tabularium 8 mm large (5 mm on average in *L. araneum*). Its dissepimentarium comprises fewer rows than in *L. araneum* and its minor septa are shorter. The present specimen is similar to *L. potii* but the latter has a tabularium proportionaly larger. Finally, this specimen is very similar to unpublished material from the upper Viséan of the Campine Basin (NE Belgium, Poty, pers. comm.)

Occurrence. – *L.* sp. was collected in the upper part of the Yılanlı Formation in the Kokaksu section together with *S. asiaticum* (lower Warnantian).

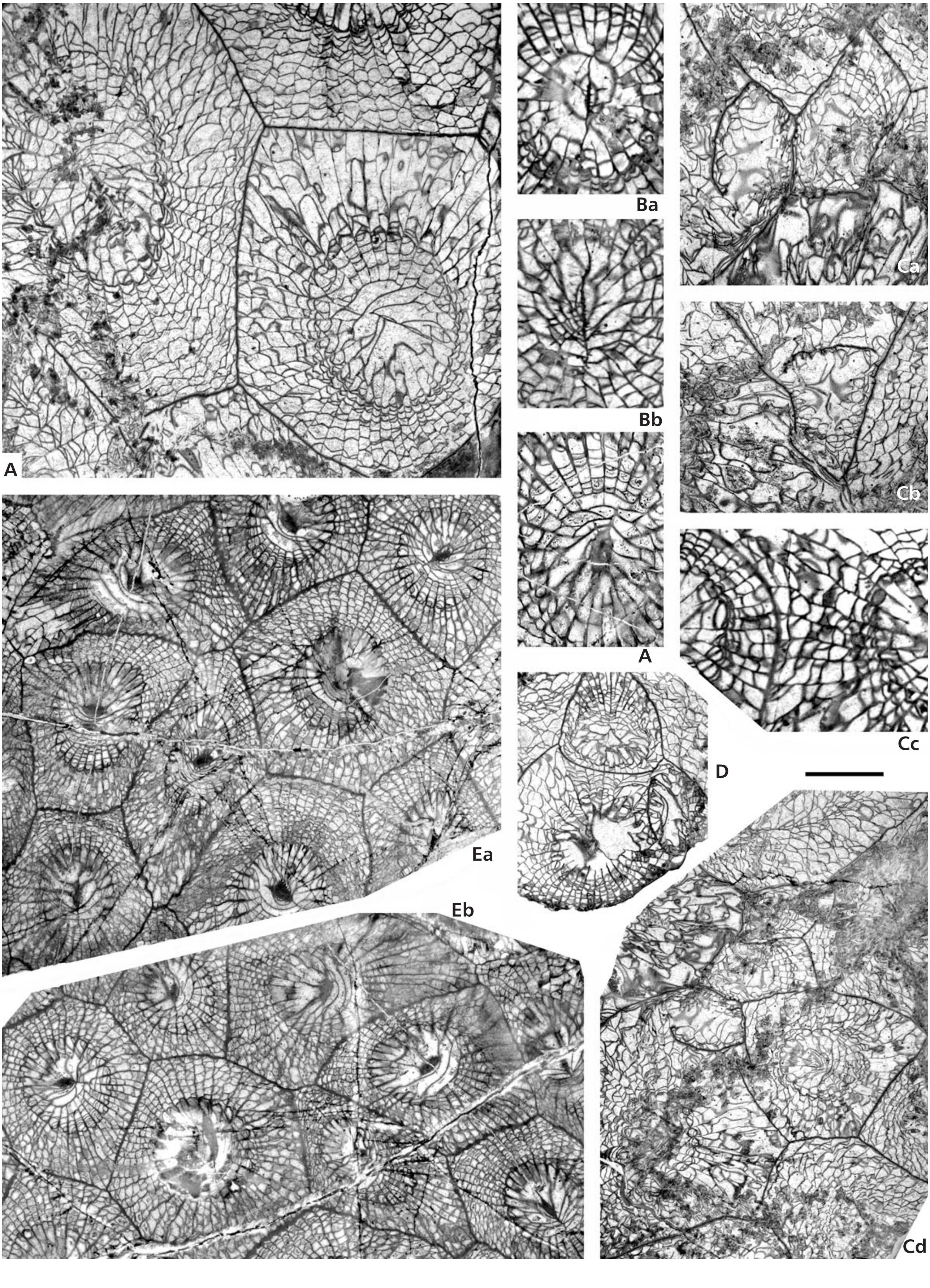
Genus *Nemistium* Smith, 1928

Type species. – *Nemistium edmondsi* Smith, 1928, Brigantian of England.

Diagnosis. – Fasciculate corals with cylindrical corallites. Major septa long reaching the axis or not. Minor septa long. Axial structure – often lacking – made of a thin columella with some septal lamellae connected to the axial ends of the septa. Dissepimentarium narrow, composed of concentric, V-shaped and herringbone interseptal dissepiments. Tabulae incomplete. Axial tabulae strongly upturned towards the columella. Increase axial, parricidal bi-, tri- or quadri-partite. Modified from Hill (1981).

Discussion. – In the original definition, Smith (1928) based his new genus on the presence of a complex axial structure but the absence or discontinuity of the columella in other species led Poty (1984) to consider this feature as a specific character more than a generic one. After Poty's (1984) phyletic model, *Nemistium* originated in *Siphonodendron* through the acquisition of a parricidal increase. In the

Figure 14. A–D – *Lithostrotion potii* sp. nov. (Moliniacian–Early Viséan); A – specimen SR.5.13 from Süzek, TS (× 2); B – SR.5.18 (holotype), Ba, Bb – close view-up of the columella, TS (× 4); C – SR.5.8 from Süzek, Ca, Cb – offsetting corallites, TS (× 4), Cc – close-up view of the dissepimentarium with minor septa of various length, TS (× 4), Cd – TS (× 2); D – SR.5.21 from Süzek, TS (× 2). • E – *Lithostrotion araneum* (McCoy, 1844) (Warnantian–Late Viséan), G.15.5 from Gökgöl, Ea, Eb – successive TS (× 2), Ec – close-up view of the columella, TS (× 4). Scale bar equals 7.5 mm for A, Cd, D, Ea, Eb and equals 3.75 mm for Ba, Bb, Ca–c, Ec.


A
Ba
Bb
A
Ca
Cb
Cc
D
Ea
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Cd

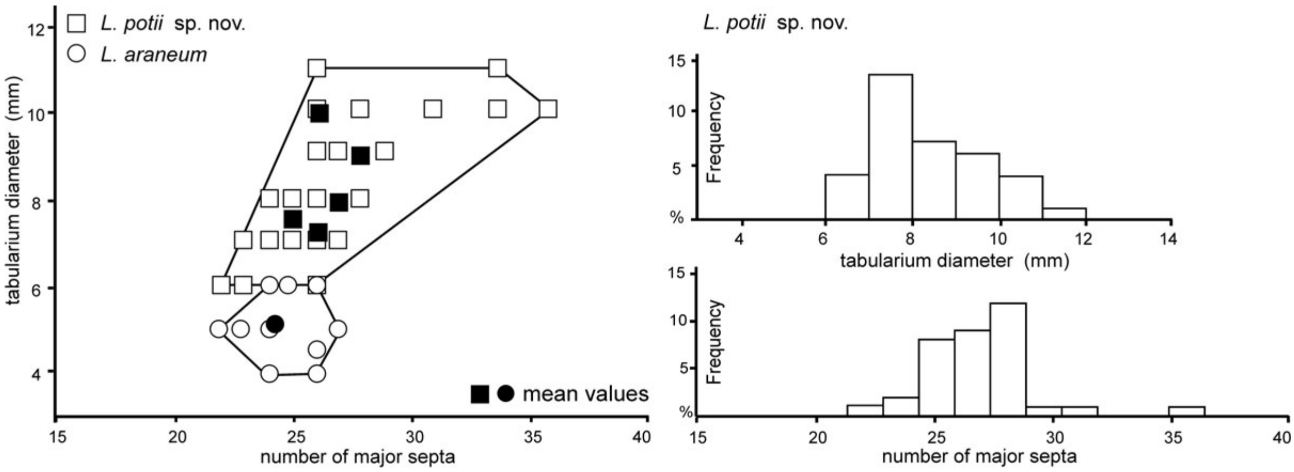

Figure 15. A – scatter diagram showing the number of septa plotted against tabularium diameter for *Lithostrotion potii* sp. nov. and *Lithostrotion araneum* (McCoy, 1844), based on 35 and 13 measurements, respectively. The mean values are given for each colony. • B – frequency histograms for the tabularium diameter and number of major septa of *Lithostrotion potii* sp. nov.

British Isles (Smith 1928), *Nemistium* appeared in the top of the late Viséan and is a guide of the Brigantian Biozone I of Mitchell (1989) and RC8 of Poty *et al*. (2006). *Nemistium* is also known in Nova Scotia (Poty 2002), Algerian Sahara (Semenoff-Tian-Chansky 1985) and Poland (Khoa 1977). The genus appears in the Russian Platform at least at the base of the upper Viséan (Dobroljubova 1958) but was described as *Siphonodendron* and *Diphyphyllum* (Poty 1984).

***Nemistium* cf. *affine* (Fleming, 1828)**
Figure 16Ca–g

Material. – A single colony from a loose block in the Sayılı quarry close to the Kisla section.

Description. – Transverse section: The mean corallite diameter is 12.2 mm (maximum 17 mm, Fig. 18). The tabularium is 9–13 mm large. There are 22–30 septa of both orders (maximum 36). The major septa extend up to the axis of the corallite. They are sinuous in the dissepimentarium but straight in the tabularium. They usually group in a cluster of 4–6 septa. The counter septum is longer and connected to the columella while the cardinal has the same length as the other septa. The minor septa are short (less than 1/3 of the major ones) and restricted to the dissepimentarium. They are sinuous and thinner than the major ones. The columella is made of an irregular plate, undulating in the small-sized corallites, tortuous and reticulated in larger corallites (Fig. 16Cd). The dissepimentarium comprises 3–6 rows of concentric or herringbone interseptal dissepiments, irregular in width. The inner row is locally thickened. The external wall is irregular in thickness (0.2 to 0.5 mm). Longitudinal section: The tabulae are incomplete, slightly convex and upturned towards the axial structure. The dissepiments are 1 mm large and 1–2 mm high, inclined at 60° towards the tabularium. There are 10–14 tabulae and 12–15 dissepiments per centimetre height.

Increase. – This specimen shows the axial quadripartite parricidal increase typical of the genus (Fig. 16Cc). The corallites divide once they are 15 mm large. The first step of the division is the disappearance of the columella, immediately followed by the withdrawal of the septa. Once freed, the tabularium is rapidly occupied by a cruciform structure, which extends towards the periphery (Fig. 16Ca, b). This structure forms the external wall of the future offsets. The septa appear on these new walls before the corallites become completely individualized (Fig. 16Cc). The columella appears before the separation of the four new corallites.

Discussion. – All the generic characters of *Nemistium* Smith, 1928 are present in that specimen. However it differs from the type species *N. edmondsi* Smith, 1928 by a larger diameter (12 mm versus 9 mm in *N. edmonsi*), by a higher number of septa (28 versus 24) and shorter major septa. The dimensions and number of septa are similar to those of *N. affine* (Fleming, 1828) but the latter has longer septa. The Turkish specimen is also similar in dimensions to the corals described under the names *Lithostrotion scoticum* and *L. dobroljubovae* in the Viséan of the Russian Platform (Dobroljubova 1958) and with *Nemistium* sp. from the Algerian Bechard Basin (Semenoff-Tian-Chansky 1985) but possesses longer septa.

Occurrence. – In the British Isles, *N. affine* (Flemings, 1828) appears relatively late in the late Warnantian (*i.e.* Brigantian Zone I of Mitchell 1989 and upper part of the

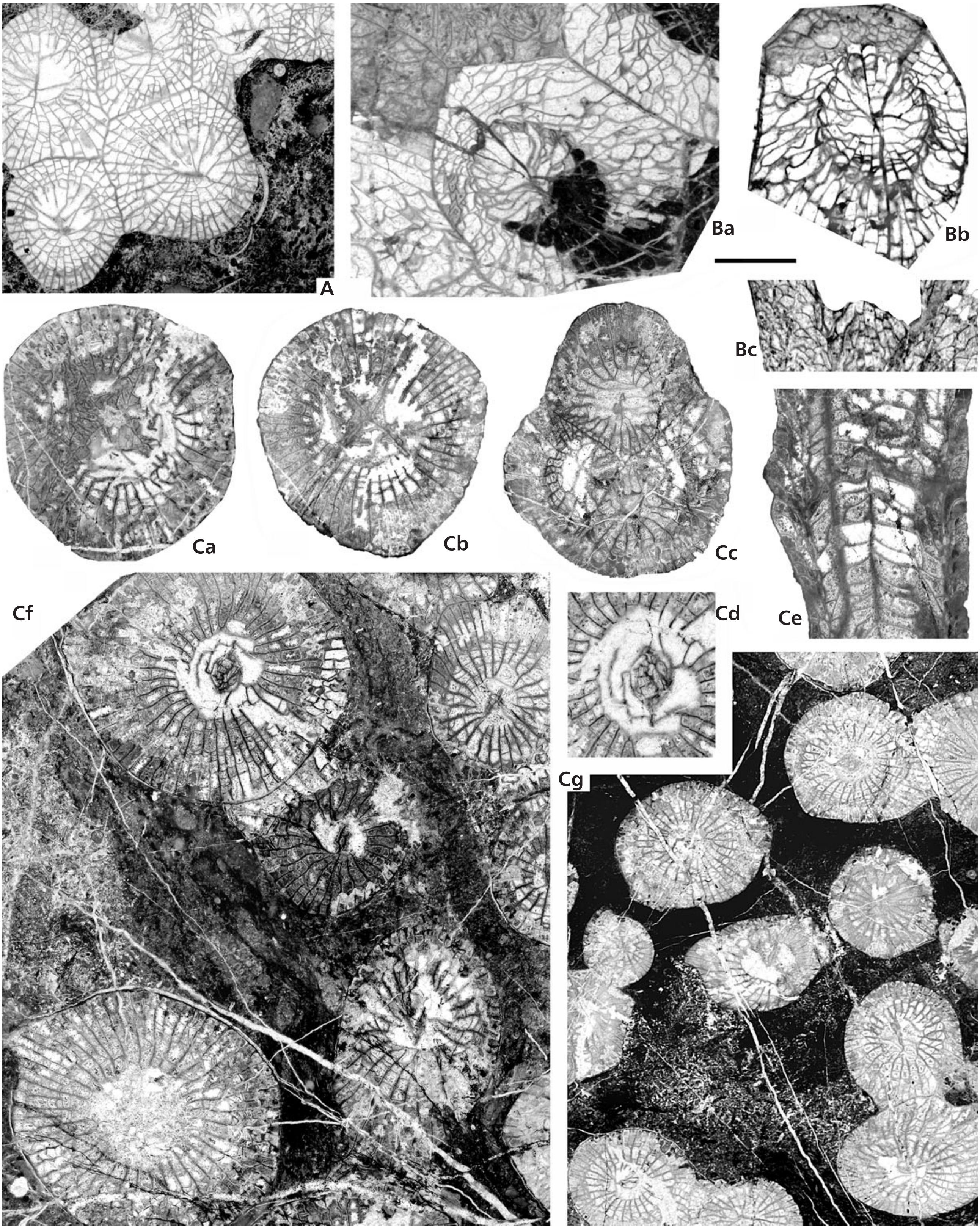

Figure 16. A – *Lithostrotion vorticale* (Parkinson, 1808), specimen K.12.6 from Kokaksu, TS (× 3). • B – *Lithostrotion* sp., K.8.3.II from Kokaksu, Ba, b – successive TS (× 3), Bc – LS (× 3). • C – *Nemistium* cf. *affine* (Fleming, 1928), S.1.1 from Kisla, Ca–c – successive TS in offsetting corallites showing a quadripartite axial division (× 3), Cd – close-up view of the axial structure, TS (× 4), Ce – LS (× 3), Cf – TS (× 3), Cg – TS (× 2). All the specimens are Warnantian (Late Viséan). Scale bar equals 5 mm for A–Cc, Ce–Cf, equals 3.75 mm for Cd and equals 7.5 mm for Cg.

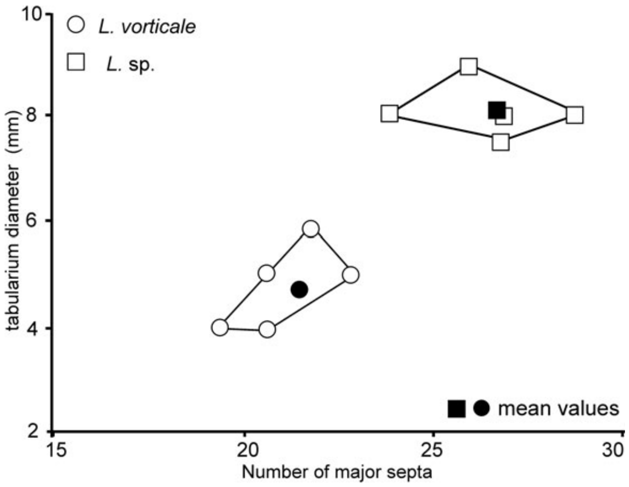

Figure 17. Scatter diagram showing the number of major septa plotted against tabularium diameter for *Lithostrotion vorticale* (Parkinson, 1808) and *Lithostrotion* sp., based on 20 and 5 measurements, respectively. The mean values are given for each colony.

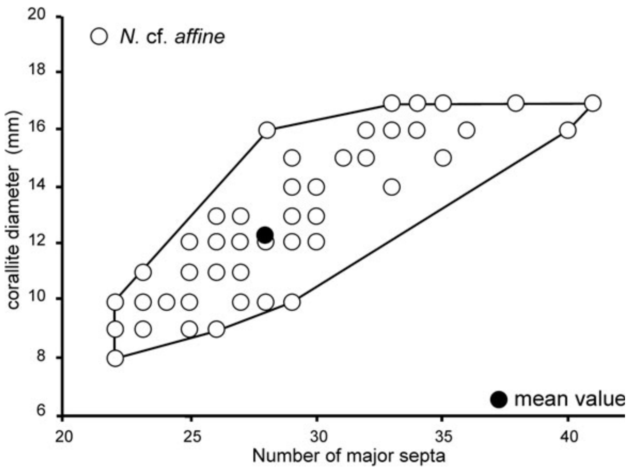

Figure 18. Scatter diagram showing the number of major septa plotted against corallite diameter for *Nemistium* cf. *affine* (Fleming, 1928), based on 60 measurements.

RC8 zone of Poty *et al.* 2006). The foraminifers associated with the specimen indicate the MFZ14 (lower Warnantian) but this age is questionable (see biostratigraphy section in the following discussions).

Discussion

Biostratigraphy

A tentative biostratigraphy, based on the vertical distribution of lithostrotionids and other colonial coral species along the four most continuous and fossiliferous sections is presented in Fig. 2. The stages and coral zones are from Poty *et al*. (2006) and Hance *et al*. (2011).

The base of the Moliniacian RC5 biozone is defined in W Europe by the first appearance of *Siphonodendron ondulosum* (Poty 1984). The first occurrence of the species was recorded in Kokaksu, Topluca and Süzek sections. *S. ondulosum* was not observed in Gökgöl, thus the base of RC5 is not well defined there. The classical subdivision into RC5α–β–γ was not recognized, as the guide taxon – *Corphalia mosae* Poty, 1975b – is not present in Turkey. Nevertheless it was possible to subdivide the RC5 in two easily identifiable subzones. RC5A is defined by the assemblage *Siphonodendron ondulosum*, *Dorlodotia briarti, Palaeosmilia murchisoni* and *Siphonodendron martini*. This zone covers the whole RC5α zone of W Europe. The second subzone – RC5B – displays an assemblage unknown in W Europe and dominated by *Dorlodotia euxinensis*, *Ceriodotia bartinensis*, *Ceriodotia petalaxoides*, *Lithostrotion potii* and *Siphonodendron* sp. A. The other taxa are species known earlier: *S. ondulosum*, *S. martini*, *D. briarti*, *P. murchisoni* and, occasionaly, *S. irregulare*, *Clisiophyllum multiseptatum*, *Siphonophyllia* sp. and a yet undescribed colonial amygdalophylloid genus. As stated above, the guide taxa of this second subzone are not present in W Europe and the correlation with the RC5β–γ of Poty *et al*. (2006) is not possible. The foraminifers associated with the RC5B coral fauna belongs to the MFZ11B as defined by Hance *et al.* (2011) based on the first appearance of primitive *Pojarkovella* together with the recently documented appearance of *Conilidiscus* ssp. (Okuyucu *et al.* 2013). The interval covered by the RC5B and MFZ11B corresponds in Belgium and British Isles, to unfossiliferous facies (mudstone, stromatolites, Poty & Hance 2006) close to the 3rd order sequence boundary number 6 of Hance *et al.* (2001) and the the gap associated to the boundary (including RC5β–γ). RC5B should thus correspond to the falling stage system tract of sequence 6 or to the lowstand system tract of sequence 7. The facies (massive bioclastic grainstone and rudstone) are more compatible with a falling stage system tract than a lowstand, but this interpretation needs to be documented and discussed.

The RC6 biozone of Poty *et al*. (2006), characterized by *S. martini*, *S. irregulare*, *L. araneum* but without *S. scaleberense* and *S. pauciradiale*, has not been identified, as the faunal association overlying the RC5B subzone is already of Warnantian age. The Livian RC6 zone is consequently lacking and the corresponding 3rd-order sequences 7 and 8 (Hance *et al.* 2001) were probably not deposited or were eroded. Even if well developed in the Namur-Dinant Basin (Belgium), the Livian sequences are usually incomplete (as in Morocco, Aretz *et al.* 2013), display siliciclastic facies (as in SE China, Hance *et al.* 2011) or are lacking entirely (as in the Campine Basin, NE Belgium: Poty *et al*. 2001). This general under-development possibly means that the Livian transgression took place during a time of worldwide

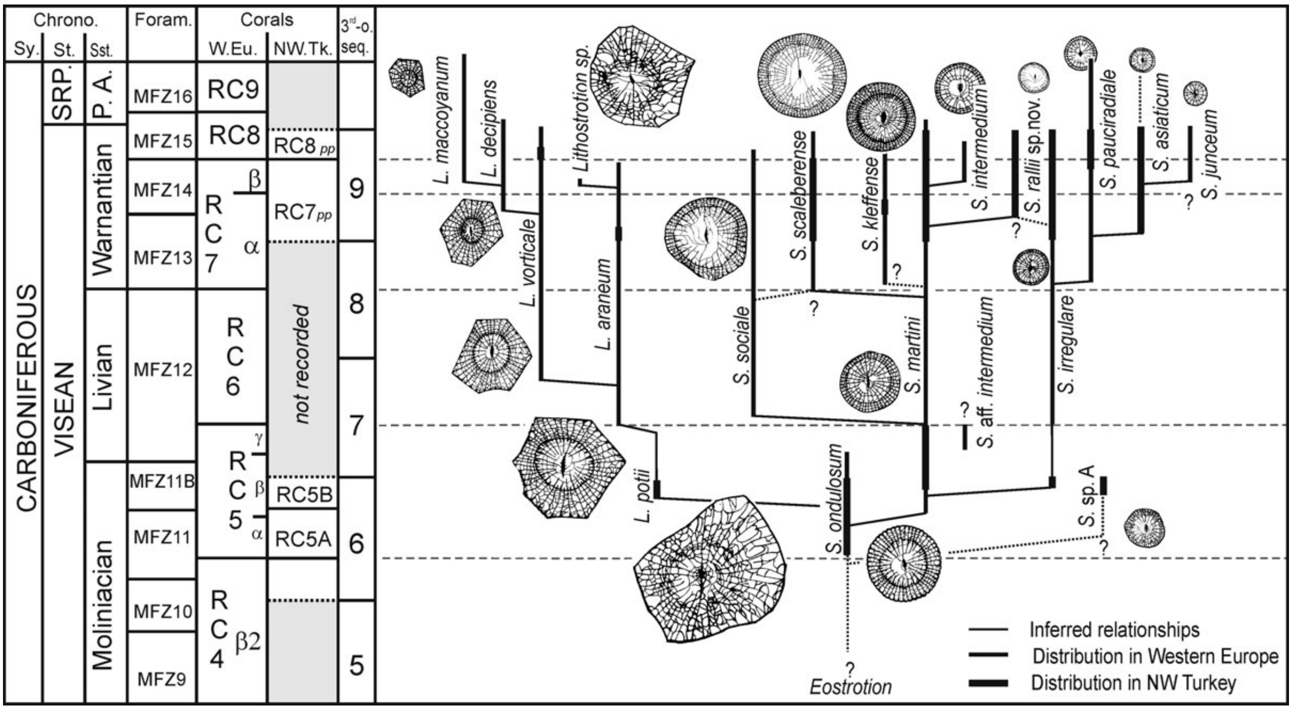

Figure 19. Stratigraphical distribution and inferred phyletic relationships between *Lithostrotion* and *Siphonodendron* species in W Europe and NW Turkey. Adapted from Poty (1984) with data from Poty (1993), Poty *et al*. (2006), Denayer *et al*. (2011) and unpublished data (Poty, pers. com.). Abbreviations: Chrono. – Chronostratigraphy, Sy. – System, St. – Stage, Sst. – substages, SRP. – Serpukhovian, P. A. – Pendleian–Arnsbergian, Foram. – foraminiferal biozones (MFZ) of Poty *et al*. (2006) and Hance *et al.* (2011), W. Eu. – W Europe, rugose corals biozones of Poty *et al*. (2006), NW Tk. – Poty's rugose coral zone adapted to NW Turkey, 3rd-o. seq. – 3rd-order sequences of Hance *et al*. (2001). Shaded time slices are not recorded in NW Turkey. Figured corals are not to scale.

low sea level (Wright & Vanstone 2001). Consequently, its absence in NW Turkey is not surprising.

The RC7 biozone (lower Warnantian) is marked, in W Europe, by the appearance of the genera *Dibunophyllum* and *Diphyphyllum* but none of them is present in NW Turkey. This zone is thus here based on the occurrence of the common species *Siphonodendron asiaticum* and *S. scaleberense*, the latter being a marker of the RC7 in Europe. The other corals are *S. martini*, *S. irregular*, *S. pauciradiale*, *S. rallii*, *S. kleffense* and *Lithostrotion araneum*. The solitary rugose corals are represented by *Aulophyllum fungites*, *Clisiophyllum* aff. *keyserlingi*, *Koninckophyllum interruptum*, *Siphonophyllia sibly* and the long-ranging *Palaeosmilia murchisoni*. The occurrence of *A. fungites*, a guide taxa of the RC7β subzone, early in the Kokaksu section argues for a much reduced RC7α subzone. For this reason and because no other taxa records the RC7α–β boundary in the studied section, it is better to consider the RC7 zone as an undivided zone.

In the Zonguldak area (Kokaksu, Kisla and Gökgöl sections), the appearance of *Palastraea konincki* (Charles, 1933) defines the base of the RC8 subzone as the genus *Palastraea* McCoy, 1851 is a guide of the British Brigantian substage. The other taxa found in this zone are mainly those of the RC7 zone, but *Lithostrotion vorticale* and *Pseudozaphrentoides* cf. *juddi* are also present. In Bartın, this zone is not recorded, the Namurian shales resting directly on limestone containing a RC7 coral assemblage.

Phylogeny

The phyletic lineage of the Lithostrotionidae proposed by Poty (1984), completed by datasets in Poty (1993) and Poty *et al.* (2006) can be emended by the Turkish material. Fig. 19 presents an updated version of Poty's model. Several remarks need to be made. i) *Siphonodendron ondulosum* presents a morphological variability higher than previously documented (*e.g*. Poty 1981, 1993; Javaux 1994). This variability includes specimens with a wide dissepimentarium that are very close to *Lithostrotion potii* corallites and probably evolved this way. ii) The paedomorphic lineage *S. ondulosum – S. martini – S. irregulare – S. pauciradiale – S. junceum* described by Poty (1984, 1993) is emended to include the species *S. asiaticum* as an intermediate (both morphological and stratigraphical) between *S. pauciradiale* and *S. junceum*. iii) The species *S. rallii* most probably evolved from *S. martini* by progenesis (see discussion of the species in the systematic section). Alternatively, *S. rallii* could have evolved from *S. irregulare* by

Table 1. Summarized occurrences of *Lithostrotion* and *Siphonodendron* species in Eurasia and North Africa. Several areas are not taken in account because of their poorly known characters and/or poor quality of their documentation. Origin of the data: NW Turkey: this paper; S Turkey (Anatolides: Denayer 2012); British Isles: Hill (1938–1941), Somerville & Rodríguez (2007); Nova Scotia: Lewis (1935) and Poty (2002), SW Spain: Rodríguez *et al.* (2002), Betic Cordillera: Herbig (1986); S France (Montagne Noire: Aretz 2002, Pyrénées: Perret & Semenoff-Tian-Chansky 1971); Brittany: Vuillemin (1990); Belgium: Denayer *et al*. (2011); Morocco (Jerada: Aretz & Herbig 2010, Adarouch: Said *et al*. 2013); Sahara: Semenoff-Tian-Chansky (1985), Aretz (2011), Aretz *et al*. (2013); Poland: Khoa (1977); Donets Basin: Vassiljuk (1960), Ogar (2010); Ural Mountains and Novaya Zemlya: Gorsky (1938, 1978); Russian Platform: Dobroljubova (1958); Kuznetsk: Fomichev (1931), Dobroljubova *et al*. (1966); Kazakhstan: Bykova (1966), Volkova (1941); Siberia and Omolon: Ivanowski (1967), Onoprienko (1976), Conil *et al*. (1982); S China and Thailand: Yü (1933), Fan *et al*. (2003), Lin *et al*. (2012), Fontaine *et al*. (1991).

	NW Turkey	S Turkey	British Isles	Nova Scotia	SW Spain	S France	Brittany	Belgium	Morocco	Sahara	Poland	Donets	Ural & Novaya Zemlya	Russian Platform	Kuznetsk	Kazakhstan	Siberia	S China
S. junceum	–	–	1	1	1	1	–	1	1	1	1	–	–	–	–	–	–	–
S. asiaticum	1	–	–	–	–	–	–	–	–	–	–	1	–	–	1	1	–	1
S. pauciradiale	1	1	1	1	1	1	–	1	1	1	1	1	1	–	–	–	1	1
S. intermedium	–	cf.	1	1	1	1	–	1	1	–	–	–	–	–	–	–	–	–
S. irregulare	1	1	1	1	1	1	–	1	1	1	1	1	1	1	–	1	–	1
S. rallii	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. martini	1	1	1	–	1	1	1	1	1	1	1	1	1	1	–	1	1	1
S. sociale	–	–	1	–	1	–	–	1	1	–	–	–	–	–	–	–	–	–
S. scaleberense	1	–	1	–	1	1	–	1	1	1	1	–	–	–	–	–	–	–
S. kleffense	1	–	–	–	cf.	–	–	1	–	cf.	–	–	–	–	–	–	–	–
S.ondulosum	1	–	1	–	–	–	–	1	–	–	–	cf.	–	–	–	–	1	–
L. maccoyannum	–	1	1	–	1	1	–	1	1	1	1	1	–	1	–	1	–	1
L. decipiens	–	1	1	–	1	1	–	1	1	1	1	–	1	1	–	–	1	1
L. vorticale	1	–	1	–	1	–	cf.	1	1	1	–	1	1	1	–	–	–	cf.
L. araneum	1	1	1	–	1	–	–	1	1	1	–	1	–	1	–	–	–	–
L. potii	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nemistium	1	–	1	1	1	1	–	–	–	1	1	–	1	1	–	1	–	–
Diphyphyllum	–	–	1	–	1	–	–	1	1	1	1	1	1	1	1	–	–	1
Orionastraea	–	–	1	–	–	–	–	–	–	–	–	–	1	1	1	–	–	1

hypermorphosis (Fig. 19). iv) While the lineage leading from *S. ondulosum* to *S. junceum* is quite clear and well documented, the evolutionary processes involved in the appearance of large species of *Siphonodendron* (*S. sociale*, *S. kleffense*, *S. scaleberense*) are less obvious. All of them possibly originated in *S. martini* but their relationships need to be documented. v) *Lithostrotion* originated in *Siphonodendron* as highlighted by Poty (1981, 1984, 1993), but *L. araneum* is not the oldest species of the genus as postulated by this author. The discovery of *L. potii* in the late Moliniacian pre-dates the appearance of the genus by at least 1.25 Ma (estimated duration of the gap between 3rd-order sequences of the lowstand of sequence 7, after Poty *et al*. 2013b). The evolution from *Siphondendron ondulosum* to *Lithostrotion potii* can be explained by a neotenic process (see discussion of the genus in the systematic section). vi) *L. potii* gave rise to *L. araneum* through progeny and the resulting paedomorphocline leads to *L. vorticale, L. decipiens* and *L. maccoyanum* as stated by Poty (1993). The species *Siphonodendron* sp. A, *Siphonodendron* aff. *kleffense* and *Lithostrotion* sp. are yet too poorly known to integrate them into the phyletic scheme.

Palaeobiogeography

Table 1 summarizes the occurrence of the species of *Lithostrotion* and *Siphonodendron* described in the present paper amongs the most well known areas bearing fossiliferous Viséan strata. The occurrences of the other genera (*Nemistium*, *Diphyphyllum* and *Orionastraea*) belonging to the Lithostrotionidae family are also provided. While some species (*S. pauciradiale*, *S. irregulare*, *S. martini*) have a very wide geographic range, the others occur in a limited number of areas (*S. sociale*, *S. kleffense*, *S. intermedium*). The latters are good palaeogeographic markers. On the other hand, the first group have only an interest in biostratigraphy, even if their first appearance can be diachronous (Poty *et al.* 2011). Table 1 aims at a comparison between the considered areas and allows the report of some trends. One of them concerns the dual palaeogeographic distribution of the species *S. junceum* and *S. asiaticum*. All regions under consideration possess one or the other but never both species. *S. junceum* is the typical small-sized species in the Western Europe Province of Sando (1990) while *S. asiaticum* has a wide distribution through the

Asian provinces (including Donets Basin and NW Turkey). This dual distribution can originate in the occurrence of both species in the same ecological niche. Considering NW Turkey, co-occurrences of Asian (*e.g. S. asiaticum*, but also *Ceriodotia* and *Kwangsiphyllum* – pers. unpub. data) and W European (*e.g. S. kleffense*, *S. ondulosum*, but also *Zaphriphyllum* and *Bounophyllum* – pers. unpublished data) taxa highlight the mixed character of the faunal association. Indeed, during the Lower Carboniferous times, the Istanbul-Zonguldak Zone was part of the southern margin of Baltica and was connected to the future Donets Basin (Stampfli *et al*. 2002, Moix *et al*. 2008). These areas were thus situated in a key position within the Palaeotethys Ocean, at the crossing between W European, E European and Asian provinces. This mixed trend is moreover observed in the foraminiferal assemblages (Dîl *et al*. 1976; Kalvoda 2002, 2003) of the Tournaisian and Viséan strata of Zonguldak.

Conclusions

The Viséan succession of Zonguldak and Bartın (NW Turkey) yielded an abundant and diversified coral fauna among which are many Lithostrotionidae. The three genera recorded are the fasciculate *Siphonodendron* and *Nemistium* and the cerioid *Lithostrotion. Nemistium* is represented by a single species: *N.* cf. *affine* but *Siphonodendron* has several species: *Siphonodendron ondulosum* ("*Lophophyllum fraiponti*" in Charles 1933), *S. martini*, *S. irregulare*, *S. pauciradiale*, *S. asiaticum*, *S. scaleberense, S. kleffense, S.* aff. *kleffense*, *S.* sp. A and the new species: *S. rallii* sp. nov. The cerioid species are *Lithostrotion potii* sp. nov., *L. araneum*, *L. decipiens* and *L.* sp. *Lithostrotion potii* sp. nov. is the oldest recorded species of the genus originated in subcerioid large corallites of *Siphonodendron ondulosum* in the latest Moliniacian. Together with species of the genera *Dorlodotia* and *Ceriodotia* and solitary rugose corals, the lithostrotionids demonstrate one more time their utility in biostratigraphy. The rugose corals RC5, RC7 and RC8 of Poty *et al.* (2006) were recognized in almost all the studied sections. The biozone RC6 is lacking due to the non-deposition or erosion of the Livian succession. This absence is also supported by foraminifers and sequence stratigraphic analysis but the latter will be described in a separate publication. The palaeogeographic distribution of the lithostrotionid corals highlights the mixed character of the Zonguldak and Bartın assemblages sharing taxa with European and Asian provinces

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