

# Fossil fungal amero-spore genera *Spirotremesporites* Dueñas and *Duenasisporonites* gen. nov.: Species diversity, morphological variations and global distribution

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## ABSTRACT

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Dispersed fossil fungal amero-spores, characterized by the presence of a single furrow which is inclined to the longer axis of the spore, are placed in the genus *Spirotremesporites* Dueñas 1979. The furrow can be of various lengths, from very short to the full length of the spore. For similar fungal spores, but with more than one furrows, a new genus *Duenasisporonites* is proposed here. Altogether, 15 species of *Spirotremesporites* and two species of *Duenasisporonites* are known so far. All these species are described in this paper. Morphological variations in these species are evaluated. Their global distribution in space and time is also discussed. The diagnoses of both the species of *Duenasisporonites*, e.g. *D. ecuatorialis* and *D. multiplex*, are emended. Various species, belonging to these genera, were recorded from throughout the Tertiary sediments (but are more commonly encountered in Middle Eocene to younger strata) of Canada (Strait of Georgia, eastern Vancouver Island, the Fraser River lowlands of southwest British Columbia), China (Leowning Province), Colombia (Sabana de Bogota), India (Renkte Kawn-Sherlui Road, Mizoram) and U.S.A. (The Gulf Coast; Henry County, Tennessee; The Green River section, Washington; Central Texas; and North-western Washington State). Several extant ascomycetous fungi, particularly among the Xylariaceae, produce spores that are similar to *Spirotremesporites*. Most of them are ubiquitous wood decaying fungi.

**Keywords:** Fossil fungal spores, *Spirotremesporites* Dueñas, *Duenasisporonites* gen. nov., morphological variations, global distribution.

## INTRODUCTION

The objective of the present paper is to record species diversity in *Spirotremesporites* Dueñas 1979 and *Duenasisporonites* gen. nov. and to study morphological variations and global distribution in space and time of various species of these genera. Dueñas (1979: 564) proposed genus *Spirotremesporites* to include ellipsoidal to elongate fungal spores possessing one or several spiralling furrows. Elsik (1990: 163)

emended the generic diagnosis to include spores having only a single furrow in contrast to the original diagnosis where spores possessing one or several spiralling furrows were included. Contrasted to the straight, longitudinally parallel furrow of *Hypoxylonites*, *Spirotremesporites* has a furrow that is set at an angle to the axis of the spore, at least for some part of the length of the furrow. Nandi et al. (2003) proposed 5 new species of *Spirotremesporites* (though none were

validly published then, later validated by Saxena 2012). They ascribed all their species of *Spirotremesporites* Elsik (1990), though the genus was effectively and validly published by Dueñas (1979). The emendation of generic diagnosis by Elsik (1990), however, does not affect any change in the authority of the genus. Therefore, citation of Elsik (1990) as author of *Spirotremesporites* (and also of its type: *S. simplex*) by Nandi et al. (2003) is considered as an inadvertent error of citation and all their species are considered to have been published under *Spirotremesporites* Dueñas (1979). This genus has affinity with Xylariaceae. *Varisulcosporites* Rouse & Mustard is a later taxonomic synonym of *Spirotremesporites* because its type species, *V. eminens*, was transferred to *Spirotremesporites* by Kalgutkar and Jansonius (2000).

#### **GLOBAL DIVERSITY IN SPIROREMESPORITES AND DUENASISPORONITES**

1. Genus: *Spirotremesporites* Dueñas 1979

**Index Fungorum Registration Identifier:** 21309.

**Type species:** *Spirotremesporites simplex* Dueñas 1979: 564, plate 3, figure 5.

**Number of species known:** Fifteen.

**Synonym:** *Varisulcosporites* Rouse & Mustard, *Palynology* 21: 208. 1997.

**Original diagnosis** (Dueñas 1979: 564, in Jansonius & Hills 1980, card no. 3769): Ellipsoidal to elongate fungal spores possessing one or several spiraling furrows.

**Emended diagnosis** (Elsik 1990: 163). Psilate, aseptate fungal spores. The aperture is a single furrow at an angle to the axis of the spore, straight or curved to S-shaped or sigmoidal in outline, or spiral around the spore axis. The furrow can be short and straight, entirely visible on one face of the spore; longer and curved; or long and spiral around the outside of the spore. The spore wall is generally rigid. The spore

outline is elongate-elliptical to oval, sometimes somewhat reniform in side view, i.e. with bilateral symmetry. The ends of the spore can be similar or dissimilar; one end can be truncated by an attachment scar.

1.1. Species: *Spirotremesporites clinatus*

Elsik 1990

Figure 1.1

**Index Fungorum Registration Identifier:** 130387.

**Original diagnosis** (Elsik 1990: 162): Bilateral, aseptate, psilate fungal spores of somewhat fusiform shape and with an elongate, curving furrow crossing the longitudinal face of the spore at an angle. Overall size ca.  $12 \times 25 \mu\text{m}$ ; spore wall rigid, ca.  $1 \mu\text{m}$ , not thickened, but is slightly protruding at the apices. The furrow is ca.  $15 \mu\text{m}$  long.

**Location and age:** The Gulf Coast; Neogene.

**Etymology:** The species epithet is derived from Latin *clinatus* = bent, sloping, slanted.

**Remarks:** Elsik (1990) stated that *Spirotremesporites clinatus* has a smaller overall size and more fusiform shape than *Spirotremesporites obliquus*.

1.2. Species: *Spirotremesporites duenasii*

Elsik 1990

Figure 1.2

**Synonym:** *Spirotremesporites simplex* Dueñas (pro parte): 162, plate 3, figure 4. 1979.

**Index Fungorum Registration Identifier:** 130384.

**Original diagnosis** (Elsik 1990: 162): Aseptate, psilate fungal spores with an elliptical outline; the outline is reniform in side view. The furrow is spiral around the axis of the spore, traversing the flat to slightly concave surface of the spore. Overall size is ca.  $9\text{--}10 \times 20\text{--}22 \mu\text{m}$ . The spore wall is ca.  $1 \mu\text{m}$  thick.

**Location and age:** Sabana de Bogota, Colombia; Pleistocene.

**Etymology:** The species epithet is in honor of

Hernando Dueñas-Jimenez.

**Remarks:** Elsik (1990) stated that *Spirotremesporites duenasii* has a relatively thick spore wall for its size. *Spirotremesporites shahejiensis* has more bluntly rounded ends and is larger. This morphotype is distinctly elliptical and reniform in outline, compared to the elongate fusiform outline of the type of *S. simplex* Dueñas 1979.

1.3. Species: *Spirotremesporites ellipticus* Nandi & Shubhra Banerjee in Saxena 2012

Figure 1.3

**Synonym:** *Spirotremesporites ellipticus* Nandi & Shubhra Banerjee in Nandi et al., Acta Palaeontologica Sinica 42(1): 60, plate 2, figure 9, text-figure 3.8. 2003, nom. inval.

**Index Fungorum Registration Identifier:** 519758.

**Original diagnosis** (Nandi et al. 2003: 60): Spores monocellate, outline narrowly elliptical, sides straight to slightly convex, ends narrowly rounded or broadly protruded. Furrow obliquely placed and crossed the longitudinal axis at an angle, long, broad, sometimes slightly curved. Exine thin surrounding the furrow, much thicker around the spore outline, surface smooth. Size range 9–10 × 28–32 µm.

**Location and age:** Renkte Kawn-Sherlui Road, Mizoram, India; Cretaceous-Tertiary (Mahadeo, Langpar, Cherra Sandstone, Siju, Bhuban, Bokabil, Tipam and Dupitila formations).

**Etymology:** The species epithet is derived from the elliptical shape of the spores.

**Remarks:** *Spirotremesporites ellipticus* resembles the ascospores of *Xylaria polymorpha* that shows short, straight to slightly curved furrow. Nandi and Banerjee in Nandi et al. (2003) did not validly publish *Spirotremesporites ellipticus* as they did not cite information on where its holotype is stored (Art. 40.5, Turland et al. 2025). Saxena (2012) validated this species by providing the missing validating information. He, however, ascribed the species to the original authors.

1.4. Species: *Spirotremesporites eminens* (Rouse & Mustard) Kalgutkar & Janson. 2000

Figure 1.4

**Synonyms:** 1. *Varisulcosporites eminens* Mustard & Rouse, Geological Survey of Canada, Bulletin 481: 143, plate 11, figure 6. 1994, nom. inval.  
2. *Varisulcosporites eminens* Rouse & Mustard, Palynology 21: 208. 1997.

**Index Fungorum Registration Identifier:** 483550.

**Original diagnosis** (Rouse & Mustard 1997: 208): Elliptical outline; spore wall laevigate and dark melanin brown, about 0.5 µm in equatorial regions, thickened to about 1.25 µm at the poles to form apical caps. Aperture a single sulcus (in holotype weakly oblique), or sometimes developed as an oblique sulcus, extended as a thin groove towards both poles, plus a second thin groove on the opposite side, also extending to the poles, possibly connecting at the poles with the two grooves coming off the main sulcus. Dimensions: range of length 22–46 µm; of width 18–20 µm.

**Location and age:** Strait of Georgia, eastern Vancouver Island, the Fraser River lowlands of southwest British Columbia, and the north-western Washington State, Canada and U.S.A.; Late Eocene-Early Oligocene.

**Remarks:** Rouse and Mustard (1997) stated that in a few specimens (plate 11, figure 5), the aperture consists of only an oblique sulcus with no extending grooves. The transfer of this species, the type of the genus *Varisulcosporites*, to *Spirotremesporites*, makes *Varisulcosporites* a later synonym of the latter.

1.5. Species: *Spirotremesporites longiletus* Nandi & Shubhra Banerjee in Saxena 2012

Figure 1.5

**Index Fungorum Registration Identifier:** 519757.

**Original diagnosis** (Nandi et al. 2003: 60): Spores solitary, ovoid-elliptical to somewhat fusiform in shape, aseptate, equatorially expanded, ends gradually and narrowly rounded. Furrow single, curved, flattened, S-

shaped, long, running along the full length of the spore axis up to the ends and crossing the longitudinal axis of the spores at an angle. Spore wall about 1.5 µm thick and smooth. Size range 35–42 × 15–25 µm.

**Location and age:** Renkte Kawn-Sherlui Road, Mizoram, India; Tertiary (Kherapara, Bhuban, Bokabil, Tipam and Dupitila formations).

**Etymology:** The species epithet is derived from the long (running along the full length of the spore axis) furrow.

**Remarks:** The ascospores with spiral furrow have been reported in some species of *Xylaria*, i.e. *X. apiculata*, *X. longiceps* and *X. persicaria* and also in *Hypoxylon*, e.g. *H. conostomum* and *H. quisquilarium* (Nandi et al. 2003). Nandi and Banerjee in Nandi et al. (2003) did not validly publish *Spirotremesporites longiletus* as they did not cite information on where its holotype is stored (Art. 40.5, Turland et al. 2025). Saxena (2012) validated this species by providing the missing validating information. He, however, ascribed the species to the original authors.

1.6. Species: *Spirotremesporites miocenicus*  
Nandi & Shubhra Banerjee in Saxena 2012

Figure 1.6

**Synonym:** *Spirotremesporites miocenicus* Nandi & Shubhra Banerjee in Nandi et al., Acta Palaeontologica Sinica 42(1): 61, plate 2, figures 8, 13, 2003, nom. inval.

**Index Fungorum Registration Identifier:** 519756.

**Original diagnosis** (Nandi et al. 2003: 61): Spores unicellate, aseptate, narrowly to broadly elliptical to dumbbell shaped, ends broadly rounded, sides straight to slightly convex, rarely slightly concave in the middle. Furrow single, long, extended one end of the spore to the other, and spirally encircles the spore body cutting the sides of the spore two times and diagonally crossed the centre. Exine thin, smooth. Size range 15–21 × 25–32 µm.

**Location and age:** Renkte Kawn-Sherlui Road,

Mizoram, India; Tertiary (Kherapara, Bhuban, Bokabil, Tipam, Dupitila and Dihing formations).

**Etymology:** The species epithet is derived from the age of the sediments (Miocene), from which these spores were recovered.

**Remarks:** *Spirotremesporites miocenicus* resembles the ascospores of some species of the modern *Xylaria*, e.g. *X. apiculata*, *X. longiceps* and *X. persicaria* and *Hypoxylon*, e.g. *H. conostomum* and *H. quisquilarium* (Nandi et al. 2003). Nandi and Banerjee in Nandi et al. (2003) did not validly publish *Spirotremesporites miocenicus* as they did not cite information on where its holotype is stored (Art. 40.5, Turland et al. 2025). Saxena (2012) validated this species by providing the missing validating information. He, however, ascribed the species to the original authors.

1.7. Species: *Spirotremesporites neogenicus*

Elsik 1990

Figure 1.7

**Index Fungorum Registration Identifier:** 130385.

**Original diagnosis** (Elsik 1990: 163): Aseptate, psilate fungal spores with an elongate elliptical outline; ends narrowly rounded. The furrow almost reaches the ends of the spore, and is shallowly inclined to the axis of the spore. Overall size of the spore ca. 9 × 19 µm; spore wall ca. 0.5 µm or less. The furrow can have a raised border of folded spore wall ca. 0.5–1.0 µm wide; the furrow is less than 0.5 µm wide. The spore wall is moderately to darkly pigmented.

**Location and age:** The Gulf Coast; Neogene.

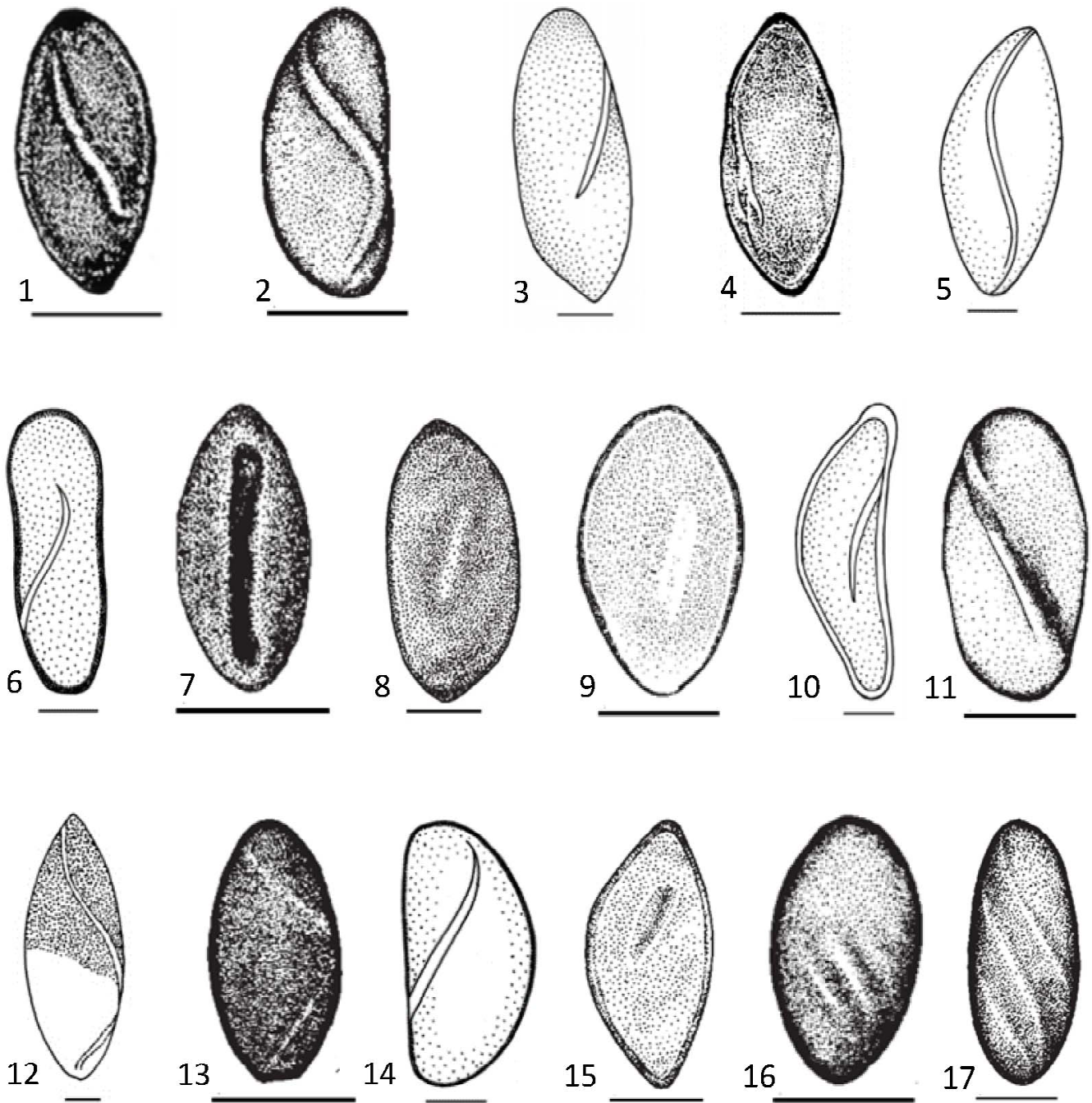
**Etymology:** The species epithet is derived from the age of the sediments (Neogene), from which these spores were recovered.

**Remarks:** *Spirotremesporites neogenicus* is similar to *Hypoxylonites fusiformis*, but has an oblique furrow.

1.8. Species: *Spirotremesporites obliquus*

Elsik 1990

Figure 1.8



**Figure 1.** 1. *Spirotremesporites clinatus* Elsik 1990. Scale Bar = 10  $\mu$ m. 2. *Spirotremesporites duenasii* Elsik 1990. Scale Bar = 10  $\mu$ m. 3. *Spirotremesporites ellipticus* Nandi & Shubhra Banerjee in Saxena 2012. Scale Bar = 6  $\mu$ m. 4. *Spirotremesporites eminens* (Rouse & Mustard) Kalgutkar & Janson. 2000. Scale Bar = 10  $\mu$ m. 5. *Spirotremesporites longiletus* Nandi & Shubhra Banerjee in Saxena 2012. Scale Bar = 7  $\mu$ m. 6. *Spirotremesporites miocenicus* Nandi & Shubhra Banerjee in Saxena 2012. Scale Bar = 5  $\mu$ m. 7. *Spirotremesporites neogenicus* Elsik 1990. Scale Bar = 10  $\mu$ m. 8. *Spirotremesporites obliquus* Elsik 1990. Scale Bar = 10  $\mu$ m. 9. *Spirotremesporites reklawensis* Elsik 1990. Scale Bar = 10  $\mu$ m. 10. *Spirotremesporites reniformis* Nandi & Shubhra Banerjee in Saxena 2012. Scale Bar = 6  $\mu$ m. 11. *Spirotremesporites shahejiensis* Elsik 1990. Scale Bar = 10  $\mu$ m. 12. *Spirotremesporites simplex* Dueñas 1979. Scale Bar = 5  $\mu$ m. 13. *Spirotremesporites subovoideus* Elsik 1990. Scale Bar = 10  $\mu$ m. 14. *Spirotremesporites tertiarus* Nandi, Shubhra Banerjee & A. Sinha in Saxena 2012. Scale Bar = 5  $\mu$ m. 15. *Spirotremesporites yeguaensis* Elsik 1990. Scale Bar = 10  $\mu$ m. 16. *Duenasisporonites ecuatorialis* (Dueñas) R.K. Saxena & P.M. Kirk, comb. nov. Scale Bar = 10  $\mu$ m. 17. *Duenasisporonites multiplex* (Dueñas) R.K. Saxena & P.M. Kirk, comb. nov. Scale Bar = 10  $\mu$ m.

**Index Fungorum Registration Identifier:** 130386.

**Original diagnosis** (Elsik 1990: 164): Aseptate, psilate fungal spores with a single, relatively short, straight furrow that is oblique to the axis of the spore. Basic outline of the spore is elliptical with fusiform ends; ends are subrounded to subpointed. The outline suggests a bilateral symmetry in side view, i.e. reniform shape. The overall size is 16–20 × 35–42 µm. The spore wall is rigid, ca. 0.5–1.0 µm. The spore wall can be slightly thickened at the ends of the spore. The furrow is 10–12 µm long.

**Location and age:** The Green River section, Washington, U.S.A.; Late Eocene.

**Etymology:** The species epithet is derived from its obliquely placed furrow (i.e. making an angle with the longitudinal axis).

**Remarks:** *Spirotremesporites obliquus* is larger and has a shorter furrow than *Spirotremesporites clinatus*. The spore wall in *S. obliquus* is occasionally slightly thickened over the ends of the spore.

1.9. Species: *Spirotremesporites reklawensis*  
Elsik 1990  
Figure 1.9

**Index Fungorum Registration Identifier:** 130387.

**Original diagnosis** (Elsik 1990: 164): Aseptate, psilate fungal spores with an irregularly elliptical to fusiform outline. The furrow is short, ca. 8–10 µm long, and inclined slightly to the axis of the spore. Overall size is ca. 8–10 × 22–25 µm. Thickness of the spore wall is ca. 0.5 µm.

**Location and age:** Texas, U.S.A.; Early Middle Eocene (Reklaw Formation of the Claiborne Group).

**Etymology:** The species epithet is derived from the rock strata (Reklaw Formation) from which these spores were recovered.

**Remarks:** *Spirotremesporites reklawensis* is smaller than *Spirotremesporites obliquus* to which it resembles.

1.10. Species: *Spirotremesporites reniformis*  
Nandi & Shubhra Banerjee in Saxena 2012

Figure 1.10

**Synonym:** *Spirotremesporites reniformis* Nandi & Shubhra Banerjee in Nandi et al., Acta Palaeontologica Sinica 42(1): 61–62, plate 2, figures 4, 6, text-figure 3.9. 2003, nom. inval.

**Index Fungorum Registration Identifier:** 519755.

**Original diagnosis** (Nandi et al. 2003: 61): Spores monocellate, aseptate, reniform shaped, sides concave towards the furrow end and convex at other side, ends narrowly rounded. Furrow single, short, obliquely placed and form 15–20° angle with the concave side of the spore. Spore wall 1.5 µm thick, smooth. Size ranges 6–10 × 28–30 µm.

**Location and age:** Renkte Kawn-Sherlui Road, Mizoram, India; Tertiary (Kherapara, Bhuban, Bokabil, Tipam and Dihing formations).

**Etymology:** The species epithet is derived from the reniform (kidney shaped) spores.

**Remarks:** Nandi et al. (2003) stated that ascospores of many genera of modern Xylariaceae are characterized by having helical to slightly oblique furrow, e.g. *Xylaria polymorpha*. Nandi and Banerjee in Nandi et al. (2003) did not validly publish *Spirotremesporites reniformis* as they did not cite information on where its holotype is stored (Art. 40.5, Turland et al. 2025). Saxena (2012) validated this species by providing the missing validating information. He, however, ascribed the species to the original authors.

1.11. Species: *Spirotremesporites shahejiensis*  
Elsik 1990  
Figure 1.11

**Synonym:** *Inapertisporites reniformis* Sheffy & Dilcher 1971, in: Ke & Shi, Acad. Petr. Expl. Div., Planning Res. Ministry Petr. Chem. Industry and Nanking Inst. Geol. Paleont., Chinese Acad. Sci., Kexue Chubanshe, Peking: 31, plate 1, figure 4. 1978. (holotype designated by Elsik 1990).

**Index Fungorum Registration Identifier:** 130388.

**Original diagnosis** (Elsik 1990: 164): Aseptate, psilate fungal spores. Spore outline elliptical with bluntly rounded ends. One furrow oblique to the axis of the spore, straight for most of the length of the spore except for near the ends where it wraps sharply around the sides of the spore. Overall size ca.  $16 \times 28 \mu\text{m}$ . Spore wall ca.  $0.8 \mu\text{m}$  thick.

**Location and age:** Leowning Province, China; Eocene-Oligocene (Shahejie Formation).

**Etymology:** The species epithet is derived from the rock strata (Shahejie Formation) from which these spores were recovered.

**Remarks:** Elsik (1990) stated that *Spirotremesporites shahejiensis* is unique in the character of the broadly rounded ends of the spore caused by the distinctly elongated sigmoidal shape of the furrow.

1.12. Species: *Spirotremesporites simplex*  
Dueñas 1979

Figure 1.12

**Index Fungorum Registration Identifier:** 112637.

**Original diagnosis** (Dueñas 1979: 564):  $9\text{--}10 \times 20\text{--}40 \mu\text{m}$  (holotype  $15 \times 37 \mu\text{m}$ ); unicellular, with a single groove running from pole to pole in a spiraling fashion; wall surface smooth, wall ca.  $1 \mu\text{m}$  thick; in some grains one of the sides seems flatter than the other. (Jansonius & Hills 1980, card no. 3769).

**Emended diagnosis** (Elsik 1990: 165): Aseptate, psilate, fungal spores with a narrowly elliptical to elongate fusiform outline. The outline is slightly reniform in side view due to the surface with the furrow being less convex than the opposite side of the spore. The aperture is an elongate, shallowly S-shaped furrow in plan view; the furrow is not trochoidal or spiral, it is apparently on one side of the spore. Overall size ca.  $13 \times 37 \mu\text{m}$ ; wall thickness ca.  $1.0 \mu\text{m}$  or less.

**Location and age:** Sabana de Bogota, Colombia; Pleistocene.

1.13. Species: *Spirotremesporites subovoideus*  
Elsik 1990

Figure 1.13

**Synonym:** *Inapertisporites subovoideus* Sheffy & Dilcher (pro parte): 38, plate 15, figure 7. 1971 (holotype: only upper one of three specimens illustrated).

**Index Fungorum Registration Identifier:** 130389.

**Original diagnosis** (Elsik 1990: 165): Aseptate, psilate, fungal spores with an elliptical outline that is truncated on one end. The furrow is apparently wrapped around the spore, i.e. the spore axis, from one end of the spore to the other. Overall size is ca.  $9 \times 20 \mu\text{m}$ , spore wall is between  $0.5$  and  $1 \mu\text{m}$  thick. The truncated end is ca.  $3 \mu\text{m}$  wide.

**Location and age:** Henry County, Tennessee, U.S.A.; Middle Eocene (Claiborne Group).

**Etymology:** The species epithet is derived from the subovoid shape of the spores.

**Remarks:** The name *Inapertisporites subovoideus* was proposed by Sheffy and Dilcher (1971), who designated the holotype by slide number and coordinates, and identified it by giving its size (which points to the lower right specimen of three illustrated in plate 15, figure 7). The two lower specimens remain in the species *Inapertisporites subovoideus*. The uppermost of the three specimens was chosen by Elsik (1990) as the type specimen of the species *Spirotremesporites subovoideus* because its morphology does not agree with the description for *Inapertisporites subovoideus*. Elsik (1990) stated that this is the only *Spirotremesporites* species with a truncated end.

1.14. Species: *Spirotremesporites tertiarus* Nandi, Shubhra Banerjee & A. Sinha in Saxena 2012

Figure 1.14

**Synonym:** *Spirotremesporites tertiarus* Nandi, Shubhra Banerjee & A. Sinha in Nandi et al., Acta Palaeontologica Sinica 42(1): 62, plate 2, figures 5, 18, text-figure 3.10. 2003, nom. inval.

**Index Fungorum Registration Identifier:** 519754.

**Original diagnosis** (Nandi et al. 2003: 62): Spores solitary, aseptate, elliptical to subelliptical in shape, ends narrowly rounded, sides straight to narrowly convex. Furrow long, obliquely placed and crossed one side of the spore at 45° angle. Spore wall 2 µm thick, smooth. Size ranges from 12–18 × 15–26 µm.

**Location and age:** Renkte Kawn-Sherlui Road, Mizoram, India; Tertiary (Kherapara, Bhuban, Bokabil, Tipam and Dihing formations).

**Etymology:** The species epithet is derived from the Tertiary Period, the age of the sediments from which these spores were recovered.

**Remarks:** *Spirotremesporites tertiarus* resembles the ascospores of *Xylaria polymorpha* (Nandi et al. 2003). Nandi and Banerjee in Nandi et al. (2003) did not validly publish *Spirotremesporites tertiarus* as they did not cite information on where its holotype is stored (Art. 40.5, Turland et al. 2025). Saxena (2012) validated this species by providing the missing validating information. He, however, ascribed the species to the original authors.

1.15. Species: *Spirotremesporites yeguaensis*  
Elsik 1990

Figure 1.15

**Index Fungorum Registration Identifier:** 130390.

**Original diagnosis** (Elsik 1990: 165): Aseptate, psilate fungal spores with a single, relatively short, straight furrow that is oblique to the axis of the spore. The outline of the spore is fusiform; the ends are sharply rounded to subpointed. The outline suggests a bilateral symmetry in side view, i.e. the outline is more convex on the side with the furrow. The overall size is 14 × 32 µm. The spore wall is rigid, ca. 0.5 µm or slightly thicker. The furrow is ca. 12 µm long.

**Location and age:** Central Texas, U.S.A.; Late-Middle Eocene (Yegua Formation of the Claiborne Group).

**Etymology:** The species epithet is derived from

the rock strata (Yegua Formation) from which these spores were recovered.

**Remarks:** According to Nandi et al. (2003), *Spirotremesporites yeguaensis* is more distinctly fusiform in outline, whereas *S. obliquus* is more robust, more nearly elliptical in outline.

2. Genus: *Duenasisporonites* R.K. Saxena & P.M. Kirk, **gen. nov.**

**Index Fungorum Registration Identifier:** 904426.

**Type species:** *Duenasisporonites ecuatorialis* (Dueñas) R.K. Saxena & P.M. Kirk, comb. nov.

**Number of species known:** Two.

**Diagnosis:** Fungal spores unicellular, aseptate, ellipsoidal-elongate or fusiform in shape. Furrows more than one (generally 3 to 4), straight or curved, short or long, parallel to each other, visible on one face of the spore, oblique to the longer axis of the spore or extend in a spiral fashion. Spore wall generally psilate or may be scabrate, vary in thickness.

**Comparison:** *Hypoxylonites* Elsik 1990 can be differentiated from the present genus in having a single furrow parallel to the longer axis of the spore. Dueñas (1979), in the original generic diagnosis, included spores possessing one or several spiraling furrows in *Spirotremesporites*. Elsik (1990) emended the diagnosis of this genus and restricted it for spores having single furrow at an angle to the axis of the spore, straight or curved to S-shaped or sigmoidal in outline, or spiral around the spore axis. Elsik (1990) tended to interpret those forms in which more than one furrows are visible on the face facing the observer as having one long furrow that loops several times around the grain. Kalgutkar and Jansonius (2000) doubted that that is true for all species, e.g., *S. ecuatorialis*. The present author agrees with Kalgutkar and Jansonius (2000) and proposes a new genus *Duenasisporonites* to accommodate spores with more than one furrows (generally 3 to 4). *Duenasisporonites* is therefore distinguished from *Spirotremesporites* in having more than one furrows that extend at an angle to the longer axis of the spore.

**Etymology:** The name of the genus is in honor of Hernando Dueñas-Jimenez.

2.1. Species: *Duenasisporonites ecuatorialis* (Dueñas) R.K. Saxena & P.M. Kirk, **comb. nov.**

Figure 1.16

**Index Fungorum Registration Identifier:** 904427.

**Basionym:** *Spirotremesporites ecuatorialis* Dueñas, *Caldasia* 12(60): 564, plate 3, figure 9. 1979.

**Original diagnosis** (Dueñas 1979: 564): Spores unicellular, ellipsoidal, with 4–8 short spiralling furrows located in the equatorial region of the spore; surface smooth, size  $18 \times 10 \mu\text{m}$  (holotype); range in size  $13\text{--}26 \times 8\text{--}15 \mu\text{m}$ .

**Emended diagnosis** (emended hoc loco): Spores unicellular, aseptate, ellipsoidal. Size range:  $13\text{--}26 \times 8\text{--}15 \mu\text{m}$ , holotype:  $18 \times 10 \mu\text{m}$ . Furrows 4–5, short, obliquely oriented, only on one face, located in the equatorial region of the spore, Spore wall psilate.

**Location and age:** Sabana de Bogota, Colombia; Pleistocene.

2.2. Species: *Duenasisporonites multiplex* (Dueñas) R.K. Saxena & P.M. Kirk, **comb. nov.**

Figure 1.17

**Index Fungorum Registration Identifier:** 904428.

**Basionym:** *Spirotremesporites multiplex* Dueñas, *Caldasia* 12(60), 564, plate 3, figure 6. 1979.

**Original diagnosis** (Dueñas 1979: 564): Spores unicellular, ellipsoidal-elongate, with several furrows, generally 4, that extend in a spiral fashion and parallel to each other, from pole to pole; surface smooth-scabrate. Thickness of wall  $1 \mu\text{m}$ . Size  $37 \times 15 \mu\text{m}$  (holotype); range in size  $28\text{--}40 \times 10\text{--}19 \mu\text{m}$ .

**Emended diagnosis** (Elsik 1990: 163): Aseptate, psilate(?) fungal spores. The furrow extends from one end of the spore to the other, in a reflexed spiral around the axis of the spore; the furrow appears to traverse the least convex surface of the spore four times, but at a very steep angle, ca. 20–30 degrees to the axis. The spore outline is elliptical to narrowly elliptical; in side

view the spore outline is somewhat reniform. Overall size is  $10\text{--}19 \times 28\text{--}40 \mu\text{m}$ . The spore wall is ca.  $1 \mu\text{m}$  thick.

**Emended diagnosis** (emended hoc loco): Spores unicellular, aseptate, ellipsoidal-elongate, in side view the spore outline is somewhat reniform. Size range:  $28\text{--}40 \times 10\text{--}19 \mu\text{m}$ , holotype:  $37 \times 15 \mu\text{m}$ . Furrows always more than three (generally 4), that extend in a wavy fashion and parallel to each other, long, may extend from one end of the spore to the other, set at a very steep angle (ca. 20–30 degrees) to the longitudinal axis. Spore wall psilate to psilate-scabrate, ca.  $1 \mu\text{m}$  thick.

**Comparison:** *Duenasisporonites ecuatorialis* differs from the present species in being shorter and less elongate ( $13\text{--}26 \times 8\text{--}15 \mu\text{m}$ ) and in having shorter furrows.

## MORPHOLOGICAL VARIATIONS

Significant morphological variations were observed in various species of *Spirotremesporites* and *Duenasisporonites*. *Spirotremesporites* is represented by 15 species, viz. *S. clinatus* Elsik, *S. duenasii* Elsik, *S. ellipticus* Nandi & Shubhra Banerjee in Saxena, *S. eminens* (Rouse & Mustard) Kalgutkar & Janson., *S. longiletus* Nandi & Shubhra Banerjee in Saxena, *S. miocenicus* Nandi & Shubhra Banerjee in Saxena, *S. neogenicus* Elsik, *S. obliquus* Elsik, *S. reklawensis* Elsik, *S. reniformis* Nandi & Shubhra Banerjee in Saxena, *S. shahejiensis* Elsik, *S. simplex* Dueñas, *S. subovoideus* Elsik, *S. tertiarus* Nandi, Shubhra Banerjee & A. Sinha in Saxena and *S. yeguaensis* Elsik. Majority of these species are bilaterally symmetrical and are generally elongate-elliptical, subelliptical or fusiform in shape. However, some are reniform, e.g. *S. duenasii*, *S. miocenicus*, *S. reniformis* and *S. tertiarus* having one side concave to deeply concave or straight. Apices are generally rounded to broadly rounded whereas in some species, they are pointed-subpointed, e.g. *S. longiletus*, *S. simplex* and *S. yeguaensis*. In most of the species, length-breadth ratio is about 2:1. But in some cases, length is significantly more than the breadth, e.g. *S. ellipticus* ( $28\text{--}32 \times 9\text{--}10 \mu\text{m}$ ), *S. reniformis* ( $28\text{--}30 \times 6\text{--}10 \mu\text{m}$ ) and *S. yeguaensis* ( $32$

$\times 14 \mu\text{m}$ ). Spore wall is mostly psilate and varies from 0.5 to 2.0  $\mu\text{m}$  in thickness. The furrow can be of varying lengths, from very short to the full length of the spore. It is set at some angle to the longitudinal axis (e.g. *S. clinatus*, *S. ellipticus*, *S. miocenicus*, *S. reklawensis*, *S. reniformis*, *S. shahejiensis*, *S. tertiarus* and *S. yeguaensis*) or wavy/spiral (e.g. *S. duenasii*, *S. longiletus*, *S. simplex* and *S. subovoideus*).

For fungal spores similar to *Spirotremesporites*,

but with more than one furrows which are inclined to the longitudinal axis of the spore, a new genus *Duenasisporonites* is proposed here. It is represented by two species, viz. *D. ecuatorialis* (Dueñas) comb. nov. and *D. multiplex* (Dueñas) comb. nov. *D. ecuatorialis* has smooth spore wall whereas in *D. multiplex* it may be smooth-scabrate. Moreover, *D. multiplex* (28–40  $\times$  10–19  $\mu\text{m}$ ) is much larger and elongate than *D. ecuatorialis* (13–26  $\times$  8–15  $\mu\text{m}$ ) (Table 1).

**Table 1.** Morphological characters of various species of *Spirotremesporites* Dueñas and *Duenasisporonites* gen. nov. (along with sketch of the holotype of each species).


















Species	Shape and Size	Nature of furrow(s)	Spore wall	Holotype
<i>Spirotremesporites clinatus</i> Elsik 1990.	Bilateral, somewhat fusiform. Size ca. 25 $\times$ 12 $\mu\text{m}$ .	Elongate, curving, crossing the longitudinal face of the spore at an angle, ca. 15 $\mu\text{m}$ long.	Psilate, rigid, ca. 1 $\mu\text{m}$ thick, slightly protruding at the apices.	 Scale Bar = 10 $\mu\text{m}$
<i>Spirotremesporites duenasii</i> Elsik 1990.	Elliptical, outline reniform in side view. Size range ca. 20–22 $\times$ 9–10 $\mu\text{m}$ .	Spiral around the axis of the spore, traversing the flat to slightly concave surface of the spore.	Psilate, ca. 1 $\mu\text{m}$ thick.	 Scale Bar = 10 $\mu\text{m}$
<i>Spirotremesporites ellipticus</i> Nandi & Shubra Banerjee in Saxena 2012.	Narrowly elliptical, sides straight to slightly convex, ends narrowly rounded or broadly protruded. Size range 28–32 $\times$ 9–10 $\mu\text{m}$ .	Obliquely placed and crossed the longitudinal axis at an angle, long, broad, sometimes slightly curved.	Smooth, thin surrounding the furrow, much thicker around the spore outline.	 Scale Bar = 6 $\mu\text{m}$
<i>Spirotremesporites eminens</i> (Rouse & Mustard) Kalgutkar & Janson. 2000.	Elliptical outline. Size range 22–46 $\times$ 18–20 $\mu\text{m}$ .	Single, oblique, extended as a thin groove towards both poles, plus a second thin groove on the opposite side, also extending to the poles.	Laevigate and dark melanin brown, about 0.5 $\mu\text{m}$ thick in equatorial regions, thickened to about 1.25 $\mu\text{m}$ at the poles to form apical caps.	 Scale Bar = 10 $\mu\text{m}$
<i>Spirotremesporites longiletus</i> Nandi & Shubhra Banerjee in Saxena 2012.	Ovoid-elliptical to somewhat fusiform in shape, equatorially expanded, ends gradually and narrowly rounded. Size range 35–42 $\times$ 15–25 $\mu\text{m}$ .	Single, curved, flattened, S-shaped, long, running along the full length of the spore axis up to the ends and crossing the longitudinal axis of the spores at an angle.	Smooth, about 1.5 $\mu\text{m}$ thick.	 Scale Bar = 7 $\mu\text{m}$
<i>Spirotremesporites miocenicus</i> Nandi & Shubhra Banerjee in Saxena 2012.	Narrowly to broadly elliptical to dumbbell shaped, ends broadly rounded, sides straight to slightly convex. Size range 25–32 $\times$ 15–21 $\mu\text{m}$ .	Single, long, extended from one end of the spore to the other, and spirally encircles the spore body cutting the sides of the spore two times and diagonally crossed the centre.	Smooth, thin.	 Scale Bar = 5 $\mu\text{m}$
<i>Spirotremesporites neogenicus</i> Elsik 1990.	Elongate elliptical outline, ends narrowly rounded. Size ca. 19 $\times$ 9 $\mu\text{m}$ .	Almost reaches the ends of the spore and is shallowly inclined to the axis of the spore, less than 0.5 $\mu\text{m}$ wide. It can have a raised border of folded spore wall (ca. 0.5–1.0 $\mu\text{m}$ wide).	Psilate, moderately to darkly pigmented, ca. 0.5 $\mu\text{m}$ or less.	 Scale Bar = 10 $\mu\text{m}$

Table 1. Contd...

Species	Shape and Size	Nature of furrow(s)	Spore wall	Holotype
<i>Spirotremesporites obliquus</i> Elsik 1990.	Elliptical outline, ends subrounded to subpointed. Outline suggests a bilateral symmetry in side view, Size range 35–42 × 16–20 μm.	Single, relatively short, straight, oblique to the axis of the spore, 10–12 μm long.	Psilate, rigid, can be slightly thickened at the ends of the spore, ca. 0.5–1.0 μm thick.	 Scale Bar = 10 μm
<i>Spirotremesporites reklawensis</i> Elsik 1990.	Irregularly elliptical to fusiform outline. Size range ca. 22–25 × 8–10 μm.	Short (ca. 8–10 μm long) and inclined slightly to the axis of the spore.	Psilate, ca. 0.5 μm thick.	 Scale Bar = 10 μm
<i>Spirotremesporites reniformis</i> Nandi & Shubra Banerjee in Saxena 2012.	Reniform, sides concave towards the furrow end and convex at other side, ends narrowly rounded. Size range 28–30 × 6–10 μm.	Single, short, obliquely placed and form 15–20° angle with the concave side of the spore.	Smooth, 1.5 μm thick.	 Scale Bar = 6 μm
<i>Spirotremesporites shahejiensis</i> Elsik, 1990.	Elliptical with bluntly rounded ends. Size ca. 28 × 16 μm.	Single, oblique to the axis, straight for most of the length of the spore except for near the ends where it wraps sharply around the sides of the spore.	Psilate, ca. 0.8 μm thick.	 Scale Bar = 10 μm
<i>Spirotremesporites simplex</i> Dueñas 1979.	Outline narrowly elliptical to elongate fusiform, slightly reniform in side view. Size range 20–40 × 9–10 μm.	Single groove running from pole to pole in a spiraling fashion, elongate, shallowly S-shaped, not trochoidal or spiral, apparently on one side of the spore.	Psilate, thickness ca. 1.0 μm or less.	 Scale Bar = 5 μm
<i>Spirotremesporites subovoideus</i> Elsik, 1990.	Elliptical outline that is truncated on one end. Overall size ca. 20 × 9 μm.	Apparently wrapped around the spore, i.e. the spore axis, from one end of the spore to the other.	Psilate, 0.5 to 1 μm thick. The truncated end is ca. 3 μm wide.	 Scale Bar = 10 μm
<i>Spirotremesporites tertiarus</i> Nandi, Shubhra Banerjee & A. Sinha in Saxena 2012.	Elliptical to subelliptical, ends narrowly rounded, sides straight to narrowly convex. Size range 15–26 × 12–18 μm.	Long, obliquely placed and crossed one side of the spore at 45° angle.	Smooth, 2 μm thick.	 Scale Bar = 5 μm
<i>Spirotremesporites yeguaensis</i> Elsik, 1990.	Outline fusiform with sharply rounded to subpointed ends. Size range 32 × 14 μm.	Single, relatively short, straight, oblique to the axis of the spore, ca. 12 μm long.	Psilate, rigid, ca. 0.5 μm thick or slightly thicker.	 Scale Bar = 10 μm
<i>Duenasisporonites ecuatorialis</i> (Dueñas) R.K. Saxena & P.M. Kirk, comb. nov.	Ellipsoidal. Size range 13–26 × 8–15 μm.	4–8 short spiralling furrows located in the equatorial region of the spore.	Smooth.	 Scale Bar = 10 μm
<i>Duenasisporonites multiplex</i> (Dueñas) R.K. Saxena & P.M. Kirk, comb. nov.	Ellipsoidal-elongate. Size range 28–40 × 10–19 μm.	Several furrows, generally 4, extending in a spiral fashion and parallel to each other.	Smooth-scabrate, 1 μm thick.	 Scale Bar = 10 μm

## GLOBAL DISTRIBUTION

*Spirotremesporites* species have been recorded from widespread areas, e.g. Canada, China, Colombia, India and U.S.A. and from throughout the Tertiary (but are more commonly encountered in Middle Eocene to younger strata). In Canada, *S. eminens* was recorded from the Late Eocene-Early Oligocene sediments of Strait of Georgia, eastern Vancouver Island and the Fraser River lowlands of southwest British Columbia (Rouse & Mustard 1997). In China, *S. shahejiensis* was recorded from the Shahejie Formation (Eocene-Oligocene) of Leowning Province (Ke & Shi 1978, Elsik 1990). Two species of *Spirotremesporites* were recorded from Colombia, e.g. *S. duenasii* and *S. simplex*, both from the Pleistocene sediments of Sabana de Bogota (Dueñas 1979, Elsik 1990). In addition, both the species of *Duenasisporonites*, viz. *D. ecuatorialis* and *D. multiplex* were also recorded from the same Pleistocene sediments of Sabana de Bogota, Colombia (Dueñas 1979). Several species of *Spirotremesporites* were recorded from India, e.g. *S.*

*clinatus*, *S. ellipticus*, *S. longiletus*, *S. miocenicus*, *S. reniformis* and *S. tertiarus* from the Cretaceous-Tertiary sequence (represented by Mahadeo, Langpar, Cherra Sandstone, Siju, Kherapara, Bhuban, Bokabil, Tipam, Dupitila and Dihing formations) of Renkte Kawn-Sherlui Road, Mizoram ((Nandi et al. 2003) and *S. eminens* from the Early Palaeogene (Akli Formation) from a borehole near Barakha, Barmer District, Rajasthan (Singh & Tripathi 2010). In U.S.A., Elsik (1990) recorded *S. clinatus* and *S. neogenicus* from the Neogene sediments of Gulf Coast, *S. reklawensis* from the Reklaw Formation of the Claiborne Group (Early Middle Eocene) and *S. yeguaensis* from the Yegua Formation of the Claiborne Group (Late-Middle Eocene) of Central Texas. Elsik (1990) also recorded *S. obliquus* from the Late Eocene sediments of the Green River section in Washington State. Sheffy and Dilcher (1971) described *S. subovoideus* from the Middle Eocene (Claiborne Group) of Henry County, Tennessee. *S. eminens* was recorded from the Late Eocene-Early Oligocene sediments of North-western Washington State (Tables 2, 3).

**Table 2.** Global distribution of various species of *Spirotremesporites* Dueñas and *Duenasisporonites* gen. nov. in space and time (with location, stratigraphic unit and age of their occurrence) along with relevant references.

Genus	Species	Location:	Horizon and age	Reference
<i>Spirotremesporites</i> Elsik 1990.	<i>S. clinatus</i> Elsik 1990.	The Gulf Coast, U.S.A.	Neogene.	Elsik 1990: 162, plate 1, figure 24.
		Renkte Kawn-Sherlui Road, Mizoram, North-eastern India.	Kherapara, Bhuban, Bokabil, Tipam and Dupitila formations (Tertiary).	Nandi et al. 2003: 60, plate 1, figures 7, 12.
	<i>S. duenasii</i> Elsik 1990.	Sabana de Bogota, Colombia.	Pleistocene.	Dueñas 1979: 564, plate 3, figure 4. Elsik 1990: 162.
	<i>S. ellipticus</i> Nandi & Shubhra Banerjee in Saxena 2012.	Renkte Kawn-Sherlui Road, Mizoram, North-eastern India.	Mahadeo, Langpar, Cherra Sandstone, Siju, Bhuban, Bokabil, Tipam and Dupitila formations (Cretaceous-Tertiary).	Nandi et al. 2003: 60, plate 2, figure 9, text-figure 3.8.
	<i>S. eminens</i> (Rouse & Mustard) Kalgutkar & Janson. 2000.	Strait of Georgia, eastern Vancouver Island, the Fraser River lowlands of southwest British Columbia, Canada and the North-western Washington State, U.S.A.	Late Eocene-Early Oligocene.	Mustard & Rouse 1994: 143, plate 11, figure 6 (nom. inval.). Rouse & Mustard 1997: 208.
		Borehole near Barakha, Barmer District, Rajasthan, India.	Akli Formation (Early Palaeogene),	Singh & Tripathi 2010: 10, plate 1, figure 2,
	<i>S. longiletus</i> Nandi & Shubhra Banerjee in Saxena 2012.	Renkte Kawn-Sherlui Road, Mizoram, North-eastern India.	Kherapara, Bhuban, Bokabil, Tipam and Dupitila formations (Tertiary).	Nandi et al. 2003: 60, plate 2, figures 10, 17, text-figure 3.7.
	<i>S. miocenicus</i> Nandi & Shubhra Banerjee in Saxena 2012.	Renkte Kawn-Sherlui Road, Mizoram, North-eastern India.	Kherapara, Bhuban, Bokabil, Tipam, Dupitila and Dihing formations (Tertiary).	Nandi et al. 2003: 61, plate 2, figures 8, 13.
	<i>S. neogenicus</i> Elsik 1990.	The Gulf Coast, U.S.A.	Neogene.	Elsik 1990: 163, plate 1, figure 49.

Table 2. Contd...

Genus	Species	Location:	Horizon and age	Reference
	<i>S. obliquus</i> Elsik 1990.	The Green River section, Washington, U.S.A.	Late Eocene.	Elsik 1990: 164, plate 1, figure 33.
	<i>S. reklawensis</i> Elsik 1990.	Texas, U.S.A.	Reklaw Formation of the Claiborne Group (Early Middle Eocene).	Elsik 1990: 164, plate 1, figure 41.
	<i>S. reniformis</i> Nandi & Shubhra Banerjee in Saxena 2012.	Renkte Kawn-Sherlui Road, Mizoram, North-eastern India.	Kherapara, Bhuban, Bokabil, Tipam and Dihing formations (Tertiary).	Nandi et al. 2003: 61–62, plate 2, figures 4, 6, text-figure 3.9.
	<i>S. shahejiensis</i> Elsik 1990.	Leowning Province, China.	Shahejie Formation (Eocene-Oligocene).	Ke & Shi 1978, plate 1, figure 4. Elsik 1990: 164.
	<i>S. simplex</i> Dueñas 1979.	Sabana de Bogota, Colombia.	Pleistocene.	Dueñas 1979: 564, plate 3, figure 5.
	<i>S. subovoideus</i> Elsik 1990.	Henry County, Tennessee, U.S.A.	Claiborne Group (Middle Eocene).	Sheffy & Dilcher 1971.
	<i>S. tertiarus</i> Nandi et al. in Saxena 2012.	Renkte Kawn-Sherlui Road, Mizoram, North-eastern India.	Kherapara, Bhuban, Bokabil, Tipam and Dihing formations (Tertiary).	Nandi et al. 2003: 62, plate 2, figures 5, 18, 19, text-figure 3.10.
	<i>S. yeguaensis</i> Elsik 1990.	Central Texas, U.S.A.	Yegua Formation of the Claiborne Group (Late-Middle Eocene).	Elsik 1990: 165, plate 1, figure 30.
<i>Duenasisporonites</i> R.K. Saxena & P.M. Kirk, gen. nov.	<i>D. ecuatorialis</i> (Dueñas) R.K. Saxena & P.M. Kirk, comb. nov.	Sabana de Bogota, Colombia.	Pleistocene.	Dueñas 1979: 564, plate 3, figure 9.
	<i>D. multiplex</i> (Dueñas) R.K. Saxena & P.M. Kirk, comb. nov.	Sabana de Bogota, Colombia.	Pleistocene.	Dueñas 1979: 564, plate 3, figure 6.

Table 3. World-wide representation of various species of *Spirotremesporites* Dueñas and *Duenasisporonites* gen. nov.

Country	Species recorded	Other particulars (with references)
Canada	<i>Spirotremesporites eminens</i> (Rouse & Mustard) Kalgutkar & Janson. 2000.	Strait of Georgia, eastern Vancouver Island, the Fraser River lowlands of southwest British Columbia, Late Eocene-Early Oligocene. Rouse & Mustard 1997.
China	<i>Spirotremesporites shahejiensis</i> Elsik 1990.	Leowning Province, Shahejie Formation (Eocene-Oligocene). Elsik 1990.
Colombia	<i>Spirotremesporites duenasii</i> Elsik 1990.	Sabana de Bogota, Pleistocene. Elsik 1990.
	<i>Spirotremesporites simplex</i> Dueñas 1979.	Sabana de Bogota, Pleistocene. Dueñas 1979.
	<i>Duenasisporonites ecuatorialis</i> (Dueñas) R.K. Saxena & P.M. Kirk, comb. nov.	Sabana de Bogota, Pleistocene. Dueñas 1979.
	<i>Duenasisporonites multiplex</i> (Dueñas) R.K. Saxena & P.M. Kirk, comb. nov.	Sabana de Bogota, Pleistocene. Dueñas 1979.
India	<i>Spirotremesporites clinatus</i> Elsik 1990.	Renkte Kawn-Sherlui Road, Mizoram, Kherapara, Bhuban, Bokabil, Tipam and Dupitila formations (Tertiary). Nandi et al. 2003.
	<i>Spirotremesporites ellipticus</i> Nandi & Shubhra Banerjee in Saxena 2012.	Renkte Kawn-Sherlui Road, Mizoram, Mahadeo, Langpar, Cherra Sandstone, Siju, Bhuban, Bokabil, Tipam and Dupitila formations (Cretaceous-Tertiary). Nandi et al. 2003.
	<i>Spirotremesporites eminens</i> (Rouse & Mustard) Kalgutkar & Janson. 2000.	Borehole near Barakha, Barmer District, Rajasthan, Akli Formation (Early Palaeogene). Singh & Tripathi 2010.
	<i>Spirotremesporites longiletus</i> Nandi & Shubhra Banerjee in Saxena 2012.	Renkte Kawn-Sherlui Road, Mizoram, Kherapara, Bhuban, Bokabil, Tipam and Dupitila formations (Tertiary). Nandi et al. 2003.
	<i>Spirotremesporites miocenicus</i> Nandi & Shubhra Banerjee in Saxena 2012.	Renkte Kawn-Sherlui Road, Mizoram, Kherapara, Bhuban, Bokabil, Tipam, Dupitila and Dihing formations (Tertiary). Nandi et al. 2003.
	<i>Spirotremesporites reniformis</i> Nandi & Shubhra Banerjee in Saxena 2012.	Renkte Kawn-Sherlui Road, Mizoram, Kherapara, Bhuban, Bokabil, Tipam and Dihing formations (Tertiary). Nandi et al. 2003.
	<i>Spirotremesporites tertiarus</i> Nandi et al. in Saxena 2012.	Renkte Kawn-Sherlui Road, Mizoram, Kherapara, Bhuban, Bokabil, Tipam and Dihing formations (Tertiary). Nandi et al. 2003.

Table 2. Contd...

Country	Species recorded	Other particulars (with references)
U.S.A.	<i>Spirotremesporites clinatus</i> Elsik 1990.	The Gulf Coast, Neogene. Elsik 1990.
	<i>Spirotremesporites eminens</i> (Rouse & Mustard) Kalgutkar & Janson. 2000.	North-western Washington State, Late Eocene-Early Oligocene. Rouse & Mustard 1997.
	<i>Spirotremesporites neogenicus</i> Elsik 1990.	The Gulf Coast, Neogene. Elsik 1990.
	<i>Spirotremesporites obliquus</i> Elsik 1990.	The Green River section, Washington State, Late Eocene. Elsik 1990.
	<i>Spirotremesporites reklawensis</i> Elsik 1990.	Central Texas, Reklaw Formation of the Claiborne Group (Early Middle Eocene). Elsik 1990.
	<i>Spirotremesporites subovoideus</i> Elsik 1990.	Henry County, Tennessee, Claiborne Group (Middle Eocene). Sheffy & Dilcher 1971.
	<i>Spirotremesporites yeguaensis</i> Elsik 1990.	Central Texas, Yegua Formation of the Claiborne Group (Late-Middle Eocene). Elsik 1990.

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