



Conidial fungi from the semi-arid Caatinga biome of Brazil. The genus *Menisporopsis*

Alisson Cardoso Rodrigues da Cruz^{1,4}, Marcos Fabio Oliveira Marques² and Luís Fernando Pascholati Gusmão³

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ABSTRACT

The genus *Menisporopsis* S. Hughes is characterized by synnematosous conidiomata around a central seta, phialidic conidiogenous cells and falcate to lunate 0- to 1-septate conidia with terminal setulae. Currently, nine species are included in the genus. In the course of investigating conidial fungi associated with decaying plant material in the semi-arid region of Brazil, we identified five *Menisporopsis* species: *M. kobensis* Matsush.; *M. novae-zelandiae* S. Hughes & Kendr.; *M. pirozynskii* Varghese & Rao; *M. profusa* Piroz. & Hodges; and *M. theobromae* S. Hughes. Ours represents only the second record of *M. kobensis* for the world. We present descriptions, comments, geographic distributions and illustrations for all five species, as well as a key to the recognized species.

Key words: Anamorphic fungi, Chaetosphaeriaceae, *Menisporopascus*, tropical microfungi

Introduction

The genus *Menisporopsis* S. Hughes was first introduced with the description of the species *Menisporopsis theobromae* S. Hughes, which was isolated from decaying leaves of *Theobroma cacao* L. (Malvaceae) in Ghana (Hughes 1952). This genus is characterized by synnematosous conidiomata that surround a central, simple, dark brown seta, phialidic conidiogenous cells and lunate to falcate 0- to 1-septate conidia with terminal setulae.

Although only nine species of *Menisporopsis* are currently recognized, a total of ten species have been described for the genus (Seifert *et al.* 2011). *Menisporopsis ludoviciana* (J.L. Crane & Schokn.) P.M. Kirk & B. Sutton, proposed from *Chaetopsina ludoviciana* J.L. Crane & Schokn. (Kirk & Sutton 1985), exhibits a branched seta and bacilliform conidia without terminal setulae, thus differing from the nine other species of the genus. Castañeda Ruiz *et al.* (1997) proposed placing this species within the genus *Vermiculariopsiella* Bender. Tsui *et al.* (1999) and Castañeda Ruiz *et al.* (2001) provided keys to *Menisporopsis* that excluded *M. ludoviciana*. The majority of the *Menisporopsis* species were originally described as occurring on decaying leaves, except for *M. multisetulata* K.M. Tsui, Goh, K.D. Hyde & Hodgkiss, which was collected from submerged decomposing wood in China (Tsui *et al.* 1999). The genus *Menisporopsis* is distributed in pantropical areas (Seifert *et al.* 2011), and

M. theobromae is widespread. However, *M. anisopora* R.F. Castañeda & Iturr., *M. kobensis* Matsush., *M. multisetulata*, *M. pleioetosa* V. Rao & de Hoog, and *M. trisetulosa* Siboe, P.M. Kirk & P.F. Cannon are restricted to their type localities (Rao & de Hoog 1986; Siboe *et al.* 1999; Tsui *et al.* 1999; Castañeda Ruiz *et al.* 2001; Matsushima 2003).

Matsushima (2003) first described the teleomorph of the genus *Menisporopsis*. The new genus, *Menisporopascus* Matsush., was introduced with *Menisporopascus kobensis* and was later placed in Sordariomycetidae *incertae sedis* by Lumbsch & Huhndorf (2007). Based on preliminary studies, *Menisporopsis* was included in a clade within Chaetosphaeriaceae, which also includes representatives of the genera *Codinaea* Maire, *Codinaeopsis* Morgan-Jones, *Dictyochaetopsis* Aramb. & Cabello, *Menispora* Pers., and *Thozetella* Kuntze (Réblová *et al.* 2006; Réblová & Seifert 2008). We find it interesting that all of those genera possess phialidic conidiogenous cells and allantoid to falcate conidia with terminal setulae.

Studies using cell extracts of *Menisporopsis theobromae* have resulted in the isolation of menisporopsin A, a compound with antimalarial and antimicrobial properties (Chinworrungsee *et al.* 2004). Other *M. theobromae* isolates have been tested, and eight bioactive compounds have been identified (Chinworrungsee *et al.* 2006).

The aim of the present study was to provide descriptions, comments, details of geographic distributions, and

¹ Universidade Federal do Oeste da Bahia, Centro de Ciências Biológicas e da Saúde, Laboratório de Microbiologia, Barreiras, BA, Brazil

² Universidade do Estado da Bahia, Departamento de Educação, Campus VII, Laboratório de Microbiologia, Senhor do Bonfim, BA, Brazil

³ Universidade Estadual de Feira de Santana, Departamento de Ciências Biológicas, Laboratório de Micologia, Feira de Santana, BA, Brazil

⁴ Author for correspondence: alisson.cruz@ufob.edu.br

illustrations for all *Menisporopsis* species associated with plant litter in the semi-arid region of Brazil. We also provide a dichotomous key to the recognized species within the genus.

Material and methods

During several expeditions carried out between 2004 and 2006 in the Serra da Jibóia Mountain Range (12°51'S; 39°28'W), we collected specimens of the genus *Menisporopsis* from a fragment of Atlantic Forest within the vegetation formation known as *caatinga* (shrublands, hereafter Caatinga Biome), in the municipality of Santa Terezinha, located in the state of Bahia, Brazil. Plant litter samples were placed in separate paper bags and taken to the laboratory. Samples were washed as described by Castañeda Ruiz (2005), after which they were placed in Petri dishes and incubated for 30 days, in moist chambers at 25°C, within polystyrene containers (150-L capacity), together with 500 ml of sterile water plus 2 ml of glycerol. The samples were scanned in stereoscopic microscope at regular intervals. Reproductive structures of fungi were removed and mounted in resin composed of polyvinyl alcohol, lactic acid, and phenol. Slides were deposited in Herbarium of Universidade Estadual de Feira de Santana (HUEFS).

Taxonomy

Menisporopsis kobensis Matsush., Matsush. Mycol. Mem. 10: 141. 2003.

Fig. 1a-c

Setae septate, erect, straight or slightly flexuous, simple, smooth, brown, 150.0-440.0 × 6.0-7.5 µm. Conidiomata synnematos, erect, straight or slightly flexuous, brown at the base to pale brown toward the apex, 114.0-225.0 × 12.0-31.5 µm. Conidiogenous cells monophialidic, integrated, cylindrical, smooth. Conidia solitary, 0-septate, allantoid, aggregated into a slimy mass, hyaline, 16.0-25.0 × 3.0-4.0 µm, with one setula at each end, 6.5-9.0 µm long.

Notes: *Menisporopsis kobensis* and its teleomorph, *Menisporopascus kobensis* Matsush., were described on fragments of a decaying dicotyledonous plant in Kobe, Japan (Matsushima 2003). The species differs from *Menisporopsis theobromae* by having larger conidia (Tab. 1). The morphological characteristics of the studied specimens are consistent with the description provided by Matsushima (2003), although the setae and conidia are shorter than those reported in the original study. This constitutes the second record of this species for the world and the first for Brazil.

Specimen examined: **BRAZIL. Bahia:** Santa Terezinha, on decaying petioles of an unidentified dicotyledonous plant, 17/II/2006, M.F.O. Marques (HUEFS 192229).

Known distribution: Japan (Matsushima 2003).

Menisporopsis novae-zelandiae S. Hughes & W.B. Kendr., N.Z. J. Bot. 6: 369. 1968.

Fig. 1d-f

Setae septate, erect, straight or slightly flexuous, simple, smooth, dark brown at the base to pale brown at the apex, 150.0-440.0 × 6.0-7.5 µm. Conidiomata synnematos, erect, straight or slightly flexuous, conidiophores initially surrounding the setae, becoming arranged laterally to it, dark brown at the base to brown toward the apex, 114.0-225.0 × 12.0-31.5 µm. Conidiogenous cells monophialidic, integrated, cylindrical, smooth. Conidia solitary, 1-septate, lunate, aggregated into a slimy mass, hyaline, 9.5-11.0 × 1.0-1.5 µm, with one setula at each end, 3.0-5.0 µm long.

Notes: *Menisporopsis novae-zelandiae* was collected from decaying leaves of *Beilschmiedia tarairi* (A.Cunn.) Kirk and *Knightsia excelsa* R.Br. in Auckland, New Zealand (Hughes & Kendrick 1968). The dimensions of the morphologic structures are in agreement with the original description, except for the small conidia in the material examined here. *Menisporopsis novae-zelandiae* exhibits distinctive characteristics, such as conidiophores forming lateral to the seta near the apex, and 1-septate conidia (Hughes & Kendrick 1968). Arias *et al.* (2010) collected specimens with polyphialidic conidiogenous cells and larger conidia. Matsushima (1975) also reported the presence of larger conidia. The species was first collected in Brazil by Dr. Hodges Jr. in the states of Paraná and Santa Catarina; however, those records have not been published (IMI database 2013). Almeida *et al.* (2011) recorded *M. novae-zelandiae* in Bahia, as part of a checklist of species found in the Caatinga Biome.

Specimens examined: **BRAZIL. Bahia:** Santa Terezinha, on dead leaves of an unidentified dicotyledonous plant, 07/IV/2005, A.C.R. Cruz (HUEFS 97972); *Ibid.*, on dead leaves of an unidentified dicotyledonous plant, 15/II/2006, M.F.O. Marques (HUEFS 192230); *Ibid.*, on decaying petioles of an unidentified dicotyledonous plant, 15/II/2006, M.F.O. Marques (HUEFS 192231); *Ibid.*, on dead leaves of an unidentified dicotyledonous plant, 17/II/2006, M.F.O. Marques (HUEFS 192232).

Known distribution: Australia (Matsushima 1989), Brazil (Almeida *et al.* 2011), Costa Rica (Mercado-Sierra *et al.* 1997a), Cuba (Delgado-Rodriguez *et al.* 2002), Ecuador (Matsushima 1993), Japan (Matsushima 1975), Mexico (Arias *et al.* 2010), Nepal (BCCM/MUCL fungi & yeasts catalogue 2013), New Zealand (Hughes & Kendrick 1968), Kenya (IMI database 2013), Taiwan (Matsushima 1980) and Venezuela (Castañeda Ruiz *et al.* 2001).

Menisporopsis pirozynskii Varghese & V.G. Rao, Bot. Notiser 131(2): 215. 1978.

Fig. 1g-i

Table 1. Synopsis of the *Menisporopsis* species described to date.

Species	Setae	Conidiomata	Conidiogenous cells	Conidia			Setulae		Type locality
	(μm)	(μm)		Shape	Septation	Size (μm)	Number	Size (μm)	
<i>M. anisospora</i>	200.0-425.0 \times 10.0-12.0	300.0-550.0 \times 60.0-80.0	Monophialidic	Allantoid to irregular, truncate at base	0-septate	17.0-30.0 \times 2.0-6.0	1 at each end; 1-3 lateral	Apical: 4.0-11.0; basal: 3.0-10.0	Venezuela
<i>M. kobensis</i>	195.0-275.0 \times 6.0-7.5	None	Monophialidic	Allantoid to lunate	0-septate or (rarely) 1-septate	16.0-32.0 \times 3.0-5.0	1 at each end	6.0-10.0 μm	Japan
<i>M. multisetulata</i>	300.0-500.0 \times 6.0-10.0	180.0-220.0 \times 22.0-40.0	Monophialidic	Allantoid	0-septate	12.0-19.0 \times 2.5-4.0	3-4 basal; 2-3 apical	Long: 7.0-10.0; short: 2.0-4.0	Hong Kong
<i>M. novae-zelandiae</i>	150.0-820.0 \times 7.2-10.8	42.0-225.0 \times 12.0-31.5	Monophialidic	Allantoid to lunate	1-septate	9.5-20.0 \times 1.0-3.5	1 at each end	3.0-8.0	New Zealand
<i>M. pirozynskii</i>	132.0-450.0 \times 3.0-14.0	35.0-250.0 \times 12.0-60.0	Monophialidic	Cylindrical to lunate	0-septate	12.0-20.5 \times 2.0-4.5	1-3 basal; 2 apical	2.0-12.0	India
<i>M. pleiosetosa</i>	100.0-300.0 \times 3.0-4.0	$\leq 250.0 \times 30.0-40.0$	Monophialidic	Ellipsoidal, truncated at base	0-septate	12.0-18.0 \times 4.0-5.0	2-4 basal; 1 apical	≤ 6.0	India
<i>M. profusa</i>	150.0-425.0 \times 4.5-9.0	60.0-225.0 \times 12.5-18.0	Polyphialidic	Cylindrical, allantoid to lunate	0-septate	7.0-15.0 \times 1.2-2.5	1 at each end	3.0-6.0	United States
<i>M. theobromae</i>	105.0-460.0 \times 4.5-7.5	55.0-170.0 \times 12.0-35.0	Monophialidic	Lunate to falcate	0-septate	11.0-20.0 \times 1.5-4.0	1 at each end	5.0-10.0	Ghana
<i>M. trisetulosa</i>	250.0-460.0 \times 5.5-7.5	None	Monophialidic	Allantoid	0-septate	12.0-20.0 \times 2.0	2 basal; 1 apical	ca. 10.0	Kenya

Setae septate, erect, straight or slightly flexuous, simple, smooth, dark brown at the base to pale brown at the apex, 275.0-400.0 \times 4.5-10.0 μm . Conidiomata synnematous, erect, straight or slightly flexuous, dark brown at the base to brown toward the apex, 95.0-145.0 \times 12.0-35.0 μm . Conidiogenous cells monophialidic, integrated, cylindrical, smooth. Conidia solitary, 0-septate, allantoid, aggregated into a slimy mass, hyaline, 12.0-18.0 \times 2.5-4.0 μm , with two setulae at each end, 8.0-10.5 μm long.

Notes: *Menisporopsis pirozynskii* is characterized by conidia with two setulae at each end. The dimensions and morphology of the reproductive structures of these specimens are in agreement with the original description (Varghese & Rao 1978). In this species, the setulae can be found in varying numbers and positions (Mouchacca 1990; Cabello *et al.* 1993; Castañeda Ruiz *et al.* 1997), however in this specimen examined were found two setulae at each end. In Brazil, the species was described for the first time from the state of São Paulo, on leaves of *Miconia cabussa* Hoehne (Gusmão *et al.* 2001).

Specimen examined: **BRAZIL. Bahia:** Santa Terezinha, on decaying petioles of an unidentified dicotyledonous plant, 07/IV/2005, A.C.R. Cruz (HUEFS 97971).

Known distribution: Argentina (Cabello *et al.* 1993), Brazil (Gusmão *et al.* 2001), Brunei (Whitton *et al.* 2012), Caledonia (Mouchacca 1990), Congo (BCCM/MUCL fungi & yeasts catalogue 2013), Cuba (Castañeda Ruiz *et al.* 1997), India (Varghese & Rao 1978), Malaysia (Matsushima & Matsushima 1996), Mexico (Begerow *et al.* 2000), Nigeria (Calduch *et al.* 2002), and Thailand (Somrithipol *et al.* 2000).

Menisporopsis profusa Piroz. & Hodges, Can. J. Bot. 51(1): 164. 1973.

Fig. 1j-l

Setae septate, erect, straight or slightly flexuous, simple, smooth, dark brown at the base to brown at the apex, 315.0-425.0 \times 6.0-9.0 μm . Conidiomata synnematous, erect, straight or slightly flexuous, brown at the base to pale brown toward the apex, 160.0-225.0 \times 12.5-18.0 μm . Conidiogenous cells polyphialidic, integrated, cylindrical, smooth. Conidia solitary, 0-septate, lunate, aggregated into a slimy mass, hyaline, 7.0-14.0 \times 1.2-2.5 μm , with one setula at each end, 3.0-5.0 μm long.

Notes: The characteristics of the studied specimens are compatible with those reported for the species; however,

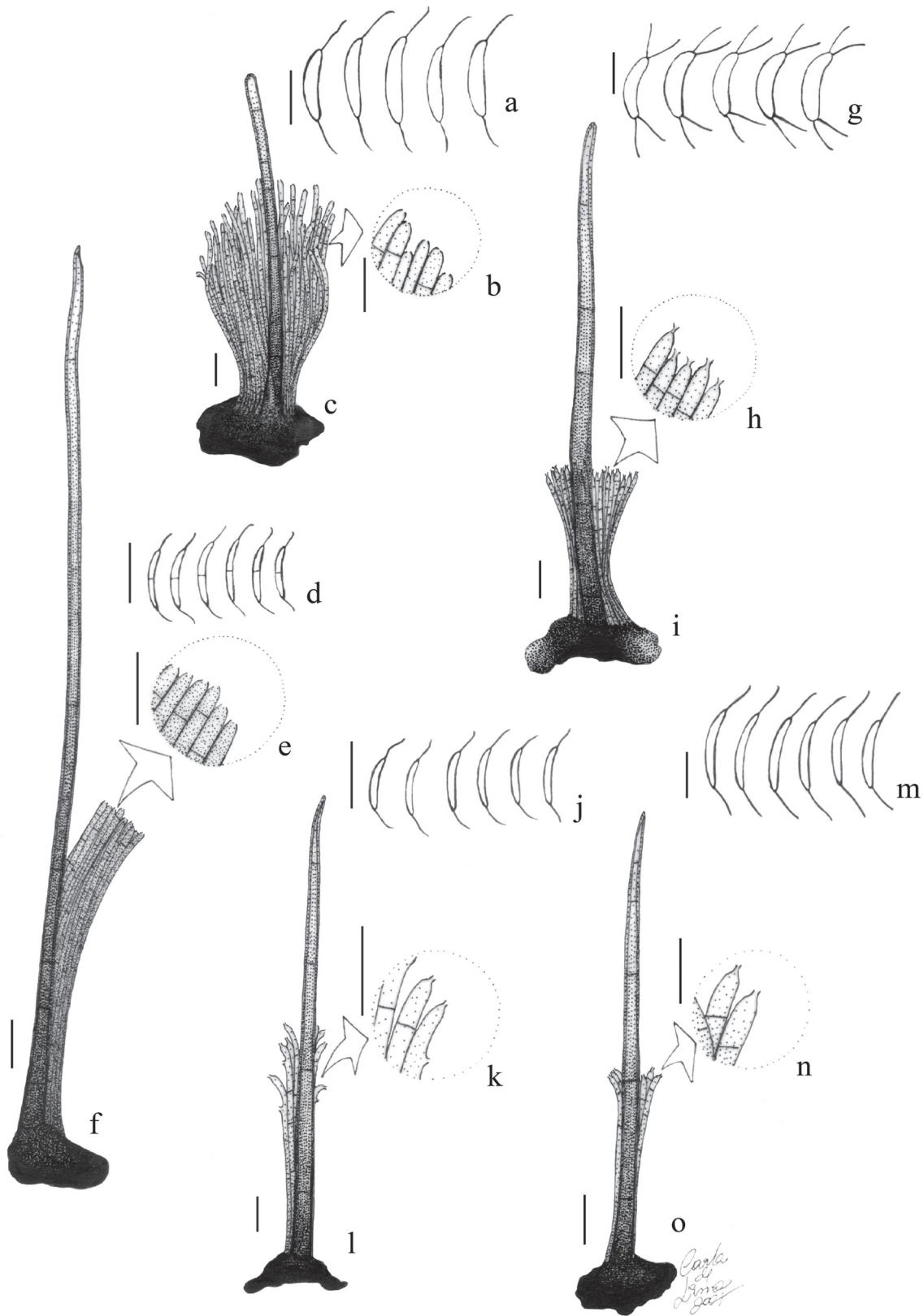


Figure 1. Species of the genus *Menisporopsis* collected in the semi-arid region of Brazil: **a-c)** *M. kobensis* Matsush. a) conidia; b) conidiogenous cells; c) conidioma—**d-f)** *M. novae-zelandiae* S. Hughes & W.B. Kendr. d) conidia; e) conidiogenous cells; f) conidioma—**g-i)** *M. pirozynskii* Varghese & V.G. Rao. g) conidia; h) conidiogenous cells; i) conidioma—**j-l)** *M. profusa* Piroz. & Hodges. j) conidia; k) conidiogenous cells; l) conidioma—**m-o)** *M. theobromae* S. Hughes. m) conidia; n) conidiogenous cells; o) conidioma. Scale bars = 10 µm (in a, b, d, e, g, h, j, k, m, and n) and 20 µm (in c, f, i, l, and o).

the conidia are smaller and the setae and conidiomata are larger than those previously described (Pirozynski & Hodges Jr. 1973, Ellis 1976). *Menisporopsis profusa* can be easily distinguished from the other species of the genus, because of the presence of polyphialidic conidiogenous cells. The species was recorded in the state of Bahia, Brazil, by Marques *et al.* (2007).

Specimens examined: **BRAZIL. Bahia:** Santa Terezinha, on dead leaves of *Clusia* sp. (Clusiaceae) 22/VII/2004, A.C.R. Cruz (HUEFS 97969); *Ibid.*, on dead leaves of an unidentified dicotyledonous plant, 12/XII/2005, M.F.O. Marques (HUEFS 192233); *Ibid.*, on decaying petioles of an unidentified dicotyledonous plant, 17/II/2006, M.F.O. Marques (HUEFS 192234); *Ibid.*, on the dead stem of an unidentified dicotyledonous plant, 21/XII/2005, M.F.O. Marques (HUEFS 192235).

Known distribution: Brazil (Marques *et al.* 2007), USA (Pirozynski & Hodges Jr. 1973) and Malaysia (Cybernome 2013).

Menisporopsis theobromae S. Hughes, Mycol. Pap. 48: 59. 1952.

Fig. 1m-o

Setae septate, erect, straight or slightly flexuous, simple, smooth, dark brown at the base to pale brown at the apex, 105.0-395.0 × 5.0-7.5 µm. Conidiomata synnematous, erect, straight or slightly flexuous, dark brown at the base to brown toward the apex, 55.0-145.0 × 12.0-35.0 µm. Conidiogenous cells monophialidic, integrated, cylindrical, smooth. Conidia solitary, 0-septate, lunate, aggregated into

slimy mass, hyaline, 11.0-15.0 × 1.5-2.5 µm, with one setula at each end, 5.0-7.5 µm long.

Notes: This species is the most widespread member of the genus, in consequence there is a remarkable morphological variability, including the unusual presence of conidia 0-1 septate such as described by Heredia-Abarca (1994). The collected specimens exhibit smaller conidia than those described by Hughes (1952). In Brazil, *M. theobromae* was collected in the state of Amapá (Batista *et al.* 1965), Paraná (Gusmão & Grandi 1997), São Paulo (Gusmão *et al.* 2001) and Bahia (Santa Izabel *et al.* 2011).

Specimens examined: **BRAZIL. Bahia:** Santa Terezinha, on dead leaves of an unidentified dicotyledonous plant, 07/IV/2005, A.C.R. Cruz (HUEFS 97970); *Ibid.*, 13/X/2005, M.F.O. Marques (HUEFS 192236); *Ibid.*, 25/IV/2006, M.F.O. Marques (HUEFS 192237); *Ibid.*, on decaying petioles of an unidentified dicotyledonous plant, 30/VI/2006, M.F.O. Marques (HUEFS 192238).

Known distribution: Australia (Matsushima 1989), Brazil (Batista *et al.* 1965), Congo (formerly Zaire, Meyer 1959), Cuba (Mercado-Sierra *et al.* 1997b), French Guiana (Kiffer *et al.* 1981), French Polynesia, Japan (CBS Filamentous fungi strain database 2013), Ghana (Hughes 1952), Ivory Coast (Rambelli *et al.* 2004), Malaysia (Cybernome 2013), Mexico (Heredia-Abarca 1994), Papua New Guinea (Matsushima 1971), Peru (Matsushima 1993), Philippines (Whitton *et al.* 2012), Puerto Rico (IMI database 2013), Taiwan (Matsushima 1980), Sri Lanka (IMI database 2013) and Venezuela (Castañeda Ruiz *et al.* 2001).

Key to species of *Menisporopsis*, adapted from Castañeda Ruiz *et al.* (2001).

1. Conidiogenous cells monoblastic..... 2
- 1'. Conidiogenous cells polyblastic..... *M. profusa*
2. Conidia truncate at the base 3
- 2'. Conidia not truncate at the base 4
3. Conidia ellipsoid, 12.0-18.0 × 4.0-5.0 µm, with 2-4 basal setulae and one apical setula *M. pleiozetosa*
- 3'. Conidia allantoid to irregular, 17.0-30.0 × 2.0-6.0 µm, always with one basal setula and one apical setula, sometimes with 1-2(3) additional lateral setula *M. anisospora*
4. Conidia with one setula at either end..... 5
- 4'. Conidia with more than one setula at both ends..... 7
5. Conidia 1-septate *M. novae-zelandiae*
- 5'. Conidia 0-septate 6
6. Conidia 16.0-32.0 × 3.0-5.0 µm *M. kobensis*
- 6'. Conidia 11.0-20.0 × 1.5-4.0 µm..... *M. theobromae*
7. Conidia with 3 setulae, one setula at either end and another near the base on the convex side *M. trisetulosa*
- 7'. Conidia with more than 3 setulae..... 8
8. Conidia 12.0-20.5 × 2.0-4.5 µm, with a total of 4-5 setulae, 2.0-12.0 µm long., 1-3 basal setulae and 2 apical setulae, one subapical on the convex side..... *M. pirozynskii*
- 8'. Conidia 12.0-19.0 × 2.5-4.0 µm, with a total of 5-6 setulae, 2.0-10.0 µm long., 3-4 basal setulae and 2-3 apical setulae, one subapical on the convex side *M. multisetulata*

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