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New records and notes on gasteroid fungi of arid regions in Argentina

F. Kuhar[1,*], V. Castiglia[1], J. C. Zamora[2] & L. Papinutti[1]

[1] Laboratorio de Micología Experimental, Departamento de Biodiversidad y Biología Experimental, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Argentina.
[2] Departamento de Micología, Real Jardín Botánico, CSIC, Plaza de Murillo 2, E-28014, Madrid, Spain.

F. Kuhar, V. Castiglia, J. C. Zamora & L. Papinutti (2012) New records and notes on gasteroid fungi of arid regions in Argentina. – Sydowia 64 (2): 233–244.

A survey of gasteroid fungi from arid regions in the La Rioja province (northwestern Argentina) resulted in 20 species of 13 genera. Each species is briefly commented on and descriptions are provided for taxa poorly known or with few records in the world. In addition, photographs of basidiomata and SEM micrographs illustrating basidiospores are provided for most of the taxa. The most noticeable records are *Bovista grandipora*, new for Argentina, *Schizostoma argentinense* with few records in the world, and *Vascellum intermedium* and *Disciseda verrucosa*, new for South America. In addition, the distribution of the species among the main types of habitat is discussed in relation to spore release and humidity.

Keywords: desert, ecology, Gasteromycetes, spore dispersion.

Gasteroid fungi are especially well represented in xeric habitats, possibly due to the relative independence of water in spore release. La Rioja belongs to the Monte biogeographical province, which is defined as a xeric biome (80–200 mm annual rainfall) according to its vegetation and physiognomy (Roig 1998, Roig-Juñent *et al.* 2001). Nevertheless, this province shows a great heterogeneity of habitats in relation to humidity, soil or terrain. Although the gasteroid mycobiota of this province was studied by Domínguez de Toledo (1989) in her doctoral dissertation and by Dios *et al.* (2004), photographs of fresh basidiomes and SEM images of Argentinian materials are frequently not available, hindering taxonomical or biogeographical conclusions. The aim of our work is to contribute to the knowledge of the species present in this region with new records and descriptions based on recently collected material, to provide SEM micrographs and images when they are needed to ascertain the identification, and to briefly discuss some taxa. We also investigate the relation between spore types and ecology in reference to the interpretation of Kreisel & Al-Fatimi (2008), who stated that smooth spores would be preferentially associated to desert landscapes while ornamented spores would mostly occur in closer association with humidity.

* e-mail: franciscokuhar@gmail.com

Materials and methods

This work is based on specimens collected in 2008, 2010 and 2012, which were deposited in the University of Buenos Aires Herbarium (BAFC) or in F. Kuhar's personal herbarium (FK). Capillitial threads and spores were observed under light (mounted in KOH 3 % w/v) or scanning electron (Zeiss DSM 982 Gemini) microscope. Basidiospore measurements were made, including the ornamentation, on at least 20 basidiospores per collection. Macroscopic measurements were made on dry basidiomata. Colors are described from well-preserved dry specimens and indicated following Maerz & Paul (1930). In order to analyze the species abundance in relation to humidity, the habitats were classified in three main types: Desert (sandy soils without vegetal covering), Monte (xerophytic steppe of *Prosopis*, *Larrea*, or *Bulnesia*), and Ravine (fluvial landforms with relatively high humidity).

Annotated species list

Battarrea phalloides (Dicks.) Pers., Syn. Meth. Fung. (Göttingen) 1: xiv, 129. 1801. – Figs. 3, 9.

Description. – Calonge (1998).

Specimens examined. – ARGENTINA, La Rioja: Cuesta de Miranda, 28° 28′ 33.59″ S 67° 42′ 27.55″ W, on sandy soil, *leg.* L. Papinutti & G. Rolón, 27 Mar 2008, BAFC 52169. La Rioja: Chilecito, 29° 10′ 32″ S, 67° 30′ 14″ W, on sandy soil, *leg.* L. Papinutti & G. Rolón, 25 Mar 2008, BAFC 52170.

Comments. – We follow Martín & Johannesson (2000) considering that *Battarrea phalloides* and *B. stevenii* (Libosch.) Fr. may represent a single variable species, or include some closely related species very difficult to distinguish based solely on morphological characters. The basidiospore ornamentation of the basidiomata studied fitted with the second clade of Martín & Johannesson (2000). This species has already been cited for La Rioja by Domínguez de Toledo (1989) as *B. stevenii*.

Bovista cunninghamii Kreisel, Nova Hedwigia, Beih. 25: 225. 1967. – Fig. 10.

Description. – Kreisel (1967).

Specimens examined. – ARGENTINA, La Rioja: Vichigasta, 29° 29′ 50″ S 67° 26′ 45″ W, *leg.* L. Papinutti & G. Rolón, 26 Mar 2008, BAFC 52171. La Rioja: Miranda, 28° 28′ 33.52″ S 67° 42′ 27.25″ W, *leg.* L. Papinutti & G. Rolón, 27 Mar 2008, BAFC 52172.

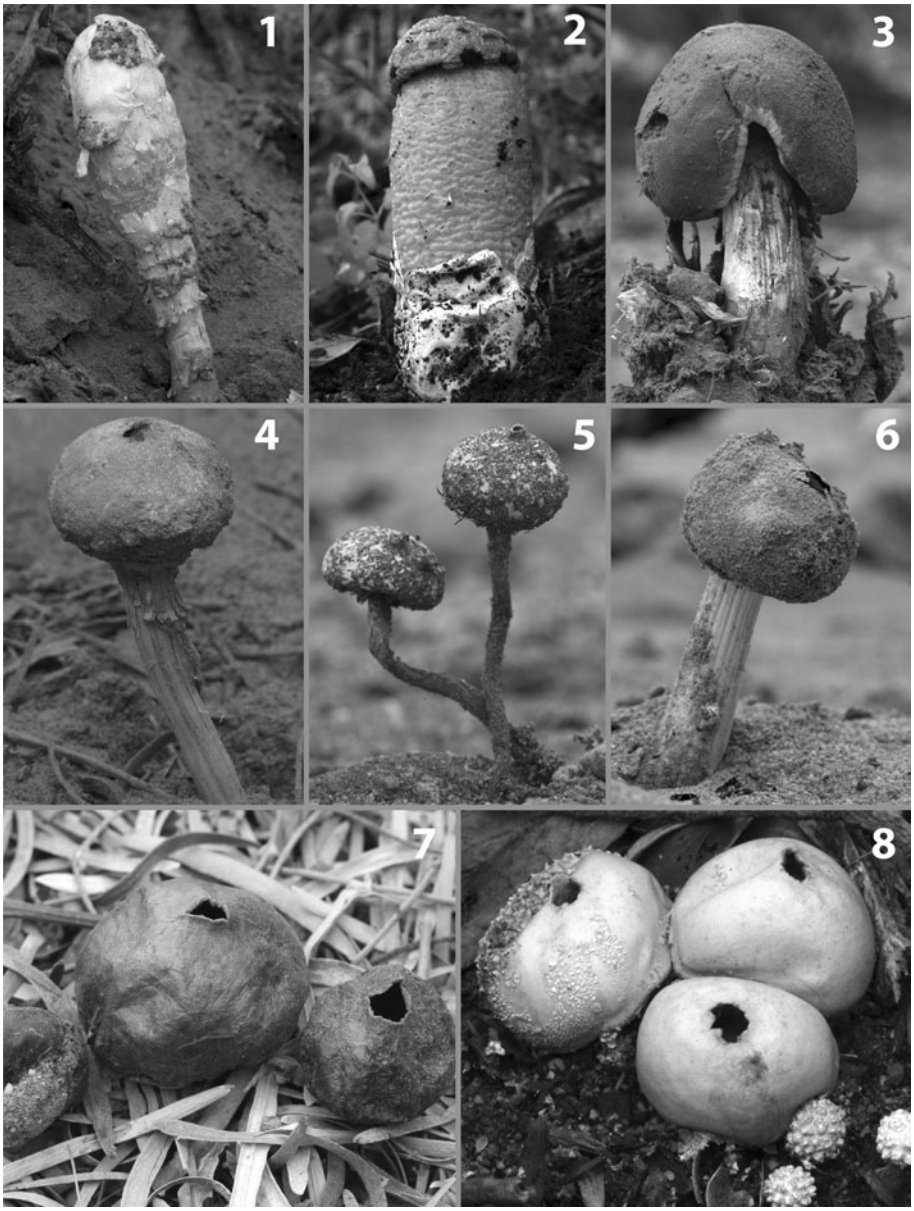
Comments. – It was previously recorded for La Rioja by Domínguez de Toledo (1989).

Bovista grandipora Trierveiler-Pereira, Kreisel & Baseia, Mycotaxon 111: 41. 2010. – Fig. 11.

Description. – Trierveiler-Pereira *et al.* (2010).

Specimen examined. – ARGENTINA, La Rioja: Miranda, 28° 28′ 33.68″ S 67° 42′ 27.55″ W, *leg.* L. Papinutti & G. Rolón, 27 Mar 2008, BAFC 52173.

Comments. – It is characterized by the absence of a subgleba, and by globose, "apedicellate" (= very shortly pedicellate, Kreisel 1967) and verrucu-



Figs. 1-8. Habit of some gasteroid fungi. **1**. *Podaxis pistillaris*. **2**. *Lysurus periphragmoides*. **3**. *Battarrea phalloides*. **4**. *Schizostoma argentinense*. **5**. *Tulostoma meridionale*. **6**. *Schizostoma laceratum*. **7**. *Disciseda stuckertii*. **8**. *Vascellum intermedium*.

lose basidiospores, with warts progressively decreasing in size toward the hilar appendix, and a capillitium of the *Lycoperdon*-type, with large pits under the light microscope and true septa. Although recently published as a new species, this taxon is very common and widespread almost all around the world, but has been previously confused with *B. delicata* Berk. & Curtis which has, however, distinctly pedicellate basidiospores (Trierveiler-Pereira *et al.* 2010). This species is recorded new for Argentina.

Calvatia rugosa (Berk. & Curtis) Reid, Kew Bull. 31(3): 671. 1977.

Description. – Bates (2004).
Specimen examined. – ARGENTINA, La Rioja: Anjullón, 28° 42′ 45″ S 66° 55′ 52″ W, *leg.* L. Papinutti & G. Rolón, 08 Apr 2012.
Comments. – This is the first record of this species in the province of La Rioja.

Chlamydopus meyenianus (Klotzsch) Lloyd, Mycol. Writings 1(14): 134. 1903

Descriptions. – Dios *et al.* (2004), Lloyd (1903), Norvell *et al.* (2008).
Specimens examined. – ARGENTINA, La Rioja: Miranda, 29° 20′ 51″ S 67° 42′ 22.16″ W, solitary on sand, *leg.* L. Papinutti & G. Rolón, 27 Mar 2008, BAFC 25174. La Rioja: Huaco, 29° 17′ 31″ S, 67° 23′ 25″ W, *leg.* L. Papinutti & G. Rolón, 15 Apr 2010, BAFC 52175.
Description. – Basidiomata 87–117 mm high; spore sac subglobose 9–17 × 17–35 mm; exoperidium not observed; endoperidium smooth, cream (12D10); ostiole apical, irregular, non protruding; gleba ferrugineous (6G12); stipe 76–104 mm high, 8–15 mm thick, becoming thinner towards base, longitudinally striate, concolorous to or slightly lighter (11C4) than spore sac. Spores globose, 5–6 µm in diam., verrucose; apiculus distinct, but of the same size as the verrucae.
Comments. – It was previously recorded from La Rioja by Domínguez de Toledo (1989) and Dios *et al.* (2004).

Disciseda bovista (Klotzsch) Henn., Hedwigia 42: 128. 1903. – Fig. 12

Descriptions. – Morales & Kimbrough (1978), Calonge (1998).
Specimen examined. – ARGENTINA, La Rioja: Miranda, 29° 20′ 51″ S 67° 42′ 22.16″ W, *leg.* L. Papinutti & G. Rolón, 27 Mar 2008, BAFC 52176.
Comments. – This is one of the most commonly recorded species of *Disciseda*. It is very close to *D. verrucosa* (see below), which often has darker basidiomata and basidiospores with longer warts and curved tips (Moreno *et al.* 2003). This is the first record of the species in La Rioja.

Disciseda stuckertii (Speg.) Moreno, Esqueda & Altés, Persoonia 19(2): 273. 2007. – Figs. 7, 13.

Description. – Moreno *et al.* (2007).
Specimen examined. – ARGENTINA, La Rioja: Anjullón, 28° 42′ 45″ S 66° 55′ 52″ W, *leg.* L. Papinutti & G. Rolón, 08 Apr 2012, FK 1201.
Comments. – The most important diagnostic character of *D. stuckertii* is the reticulate ornamentation of the basidiospores. We consider the species

as a member of the genus *Disciseda* following Moreno *et al*. (2007). Our specimen is the first finding in La Rioja.

Disciseda verrucosa G. Cunn., Trans. Proc. New Zealand Inst. 57: 205. 1926. – Fig. 14.

Description. – Moreno *et al*. (2003).

Specimen examined. – ARGENTINA, La Rioja: Saladillo, 29° 18′ 40″ S 66° 53′ 56″ W, on sandy soil, *leg.* J. C. Zamora. 07 Apr 2012, FK 1203.

Comments. – Most of the basidiomata show a grayish endoperidium with brownish tones only in a few basidiomata, much resembling *D. bovista* and agreeing perfectly with the type specimen of *D. verrucosa* (Moreno *et al*. 2003), differing from *D. bovista* in the basidiospore ornamentation (see comments on *D. bovista* above). Here, we follow the considerations of Moreno *et al*. (2003) on its synonymy with *D. arida* Velen. Our finding is the first record of this species in South America.

Geastrum fornicatum (Huds.) Hook., Curtis Fl. Londin. 4: 575. 1821

Description. – Sunhede (1989).

Specimens examined. – ARGENTINA, La Rioja: Udpinango, 28° 40′04″ S 66° 49′07″ W, on abundant litter under *Prosopis* sp., *leg.* J. C. Zamora. 09 Apr 2012, FK 1204. La Rioja: Anjullón, 28° 42′ 45″ S 66° 55′ 52″ W, under *Prosopis* sp., *leg.* L. Papinutti & J. C. Zamora, 08 Apr 2012, FK 1202.

Comments. – Although rather widespread (Sunhede 1989), we do not know any previous reports for La Rioja.

Lysurus periphragmoides (Klotzsch) Dring, Kew Bull. 35(1): 70. 1980. – Fig. 2.

Description. – Dring (1980).

Specimens examined. – ARGENTINA, La Rioja: Miranda, 29° 20′ 43″ S 67° 42′ 22.20″ W, on soil under *Juglans regia*, *leg.* L. Papinutti & G. Rolón, 27 Mar 2008, BAFC 52181.

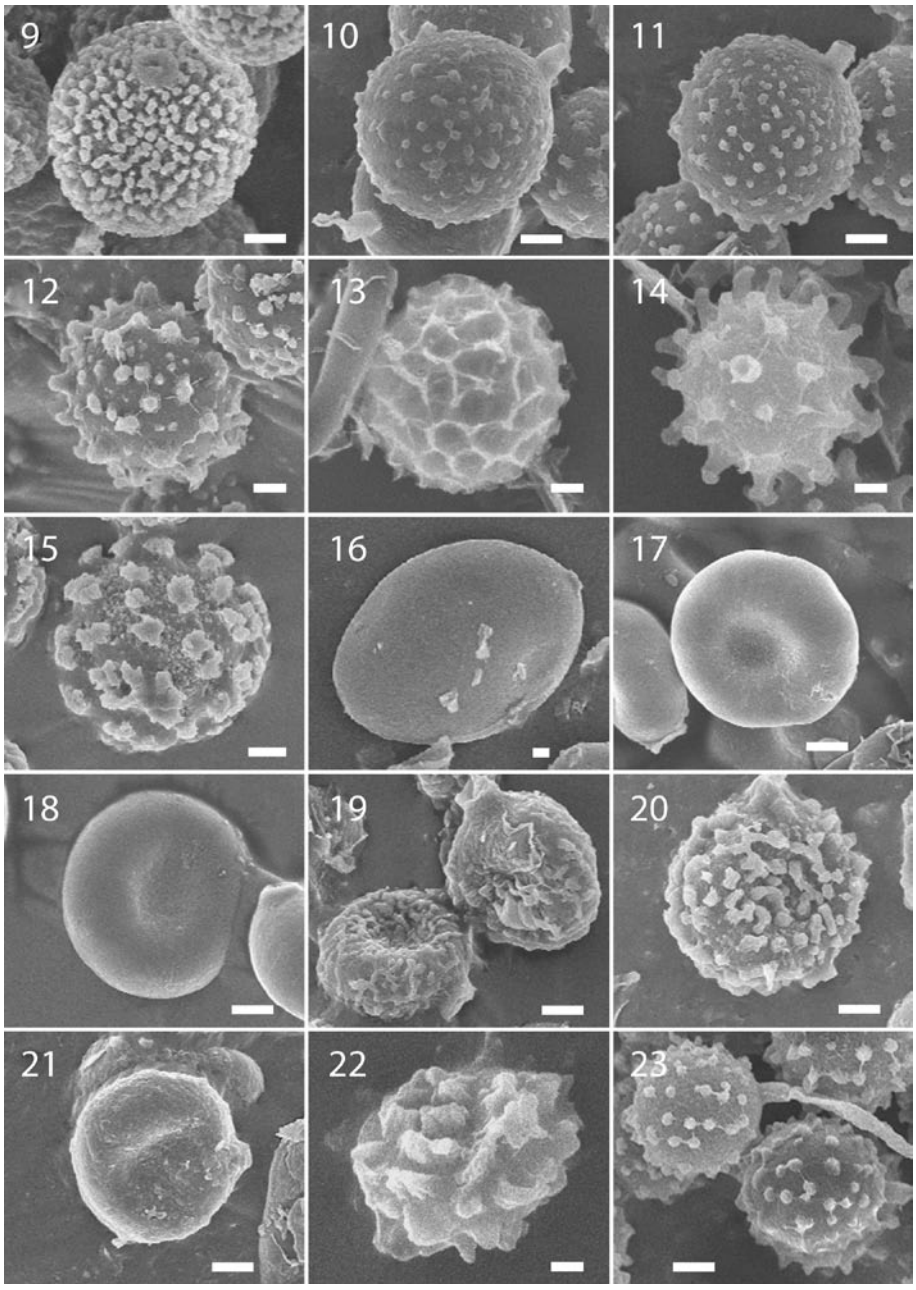
Comments. – This is the first record for La Rioja.

Montagnea arenaria (DC.) Zeller, Mycologia 35(4): 418. 1943.

Descriptions. – Domínguez de Toledo (1989), Bailey & Bailey (1985).

Specimens examined. – ARGENTINA, La Rioja: Miranda, 29° 19′ 15″ S 67° 42′ 21.30″ W, on sandy soil, *leg.* L. Papinutti & G. Rolón, 27 Mar 2008, BAFC 52182. La Rioja: Miranda, 29° 20′ 51″ S 67° 42′ 22.16″ W, *leg.* L. Papinutti & G. Rolón, 27 Mar 2008, BAFC 52183. La Rioja: Miranda, 29° 20′ 00″ S 67° 42′ 22.55″ W, on sandy soil, *leg.* L. Papinutti & G. Rolón, 27 Mar 2008, BAFC 52184.

Comments. – The basidiospore length of our specimens varies between 10–15 µm, falling in the average size of the species. Chen (1999) showed that the huge variation in the basidiospore size and shape, observed in different collections, is not linked to any phylogenetic pattern, considering *M. arenaria* as a very variable species. We follow the same taxonomic treatment here. This species has already been recorded in La Rioja by Domínguez de Toledo (1989).



Figs. 9-23. Scanning electron microphotographs of basidiospores of selected gasteroid fungi. **9**. *Battarrea phalloides*. **10**. *Bovista cunninghamii*. **11**. *B. grandipora*. **12**. *Disciseda bovista*. **13**. *D. stuckertii*. **14**. *D. verrucosa*. **15**. *Phellorinia herculeana*. **16**. *Podaxis pistillaris*. **17**. *Schizostoma argentinense*. **18.** *S. laceratum*. **19.** *Tulostoma chudaei*. **20**. *T. fimbriatum var. fimbriatum*. **21.** *T. leiosporum*. **22.** *T. meridionale*. **23.** *Vascellum intermedium*. Bars 1 µm.

Phellorinia herculeana (Pers.) Kreisel, Česká Mykol. 15(4): 196. 1961. – Fig. 15.

Descriptions. – Calonge (1998) Domínguez de Toledo (1989).

Specimens examined. – ARGENTINA, La Rioja: San Nicolás, 29° 07′ 15″ S 67° 28′ 16″ W, on soil under *Larrea* sp., *leg.* L. Papinutti & G. Rolón, 24 Mar 2008, BAFC 52185. La Rioja: Vichigasta, 29° 20′ 45.54″ S 67° 42′ 22.16″ W, on sandy soil, *leg.* L. Papinutti & G. Rolón, 26 Mar 2008, BAFC 52186.

Comments. – It has been previously found by Domínguez de Toledo (1989) in La Rioja.

Podaxis pistillaris (L.: Pers.) Fr., Syst. Mycol. 3(1): 63. 1829. – Figs. 1, 16.

Description. – Domínguez de Toledo (1989).

Specimens examined. – ARGENTINA, La Rioja: Miranda, 29° 20′ 45.54″ S 67° 42′ 22.16″ W, on sandy soil, *leg.* L. Papinutti & G. Rolón, 27 Mar 2008, BAFC 52187. Ibid., BAFC 52188. Ibid., BAFC 52199.

Comments. – The species has been previously recorded for La Rioja by Domínguez de Toledo (1989).

Schizostoma argentinense (Speg.) Long, Lloydia 11: 58. 1948. – Figs. 4, 17.

Description. – Domínguez de Toledo (1989).

Specimen examined. – ARGENTINA, La Rioja: Vichigasta, 29° 29′ 50″ S 67° 26′ 45″ W, on sandy soil, *leg.* L. Papinutti & G. Rolón, 26 Mar 2008, BAFC 52189.

Description. – Basidiomata 72 mm high; spore sac 24 mm wide, dilacerated; exoperidium remaining as hyphal aggregates at the base of the spore sac, including scarce sand debris; endoperidium grayish (5A7), smooth to subsmooth, dehiscence by irregular splitting of the entire spore sac; socket deep and clearly separated from the stipe, membranous; stipe 69 × 2 mm along the whole length, lighter than the exoperidium, not decorticating at all, but slightly striate near the spore sac; gleba brown (8L12). Spores 3.9–5.2(6.4) µm, globose, smooth; capillitium pale yellowish brown (15A12), without septa, scarcely ramified, with regularly wide lumen, not fragmented.

Comments. –This species has already been cited for the Catamarca province (Domínguez de Toledo 1989, Dios 2011) but this is the first record for La Rioja.

Schizostoma laceratum (Ehrenb.: Fr.) Lév., Ann. Sci. Nat. Bot. 5: 165. 1846. – Figs. 6, 18.

Description. – Domínguez de Toledo (1989).

Specimen examined. – ARGENTINA, La Rioja: Vichigasta, 29° 29′ 00″ S 67° 31′ 00″ W, gregarious, on sand without vegetation, *leg.* L. Papinutti & G. Rolón, 26 Mar 2008, BAFC 52190.

Description. – Basidiomata 65–83 mm high; spore sac 16–22 mm wide, 11–15 mm high, globose to subglobose; exoperidium hyphal to indistinct, including sand debris, deciduous; endoperidium whitish (11B3), smooth to subsmooth; ostiole consisting in an irregularly lacerate aperture, plane, and without a characteristic margin; socket deep and

clearly separated from the stipe, membranous; stipe 47–68 × 7–8 mm under the spore sac and becoming thinner at the base, concolorous with the endoperidium, decorticating in broad scales; gleba brown (8L10). Spores globose, smooth, 4.9–5.1 µm wide; capillitium consisting in both long and short moderately thin-walled and undulating fibers bearing very short ramifications.

Comments. – The microscopic characteristics agree fairly well with this species, although the dehiscence of the endoperidium goes through a rather rounded, but lacerate ostiole. However, as previously noted by Calonge (1998), *Tulostoma volvulatum* I. G. Borshchov is likely a synonym of *Schizostoma laceratum*, because the differences of the dehiscence of the endoperidium can be explained by the different degree of maturity of the basidiomata. Moreno *et al*. (1994) have previously noted that these species are difficult to distinguish, although they keep them separated, mainly based on peristome and capillitium characters. They also commented that *T. cretaceum* belongs to a species complex that needs a revision. Studying other species of the *T. volvulatum* group in Wright's (1987) monograph, we have the impression that there are other not well delimited taxa, usually rather difficult to distinguish from *T. volvulatum*, such as *T. albocretaceum* Long & Ahmad, *T. cretaceum* Long, *T. fusipes* Hariot & Pat., *T. meristostoma* Long, and *T. vulgare* Long & Ahmad. At present, without a thorough revision of that group including molecular data, we prefer to follow the most conservative taxonomic treatment and considered the specimens studied as *Schizostoma laceratum*, keeping in mind that some of the mentioned species might be conspecific with it as well. This species has been recorded by Domínguez de Toledo (1989) in the Talampaya National Park (La Rioja).

Tulostoma chudaei Pat., Bull. Soc. Mycol. France 23: 84. 1907. – Fig. 19.

Description. – Wright (1987).

Specimens examined. – ARGENTINA, La Rioja: Chilecito, 29° 09′ 11.20″ S 67° 29′ 34.18″ W, *leg.* L. Papinutti & G. Rolón, 25 Mar 2008, BAFC 52191.

Comments. – This is one of the most common species in Argentina (Wright 1978), recorded in many provinces, but our collection is the first one for La Rioja. It is easy to distinguish by the robust habit, the easily removable stipe, the hyphal exoperidium forming a very thick band under the endoperidium, and the sporal morphology. It is apparently close to or even conspecific with *T. balanoides* Long & Ahmad, because the only difference between the two seems to be the spore size (Wright 1987).

Tulostoma fimbriatum Fr., Syst. Mycol. 3: 1169. 1821. var. ***fimbriatum***. – Fig. 20.

Description. – Wright (1987).

Specimens examined. – ARGENTINA, La Rioja: Miranda, 29° 20′ 43″ S 67° 42′ 22.20″ W, on soil under *Larrea* sp., *leg.* L. Papinutti & G. Rolón, 27 Mar 2008, BAFC 52192.

Comments. – It is one of the most common species all around the world (Wright 1987). Being rather variable in its macro- and micromorpho-

logical characters, a number of varieties have been described, but our sample agrees quite well with the typical variety in the sense of Wright (1987). This species was found by Dios *et al.* (2004) in La Rioja.

Tulostoma leiosporum R. E. Fr., Ark. Bot. 8(11): 28. 1908. – Fig. 21.

Description. – Wright (1987).

Specimens examined. – ARGENTINA, La Rioja: Vichigasta, 29° 29′ 09″ S 67° 25′ 00″ W, gregarious, on sand, *leg.* L. Papinutti & G. Rolón, 26 Mar 2008, BAFC 52193. ibid. BAFC 52194.

Comments. – The closest species to our samples in Wright's (1987) monograph are *T. leiosporum* and *T. puncticulosum* Long & Ahmad. Moreno *et al.* (1997) studied type materials of these two taxa, finding different species mixed together and selecting specimens with subsmooth basidiospores as lectotypes in both cases. Furthermore, as the type materials showed a close similarity, they proposed the synonymy of these species, including *T. operculatum* Long & Ahmad as a synonym as well, and being *T. leiosporum* the correct name for this taxon due to priority (Moreno *et al.* 1997). The morphological differences stated by Wright (1987) can be reduced to the spore size (3.5–4.9 µm in *T. leiosporum* vs. 4.2–5.9 µm in *T. puncticulosum*), and the more or less deciduous exoperidium in *T. leiosporum*, persistent in *T. puncticulosum*. Here we followed Moreno *et al.* (1997) and regarded those differences as a part of the variability of the species. This is the first record of this species for La Rioja.

Tulostoma meridionale J. E. Wright, in Wright, Herrera & Guzmán, Ciencia (México) 27(4–5): 117. 1972. – Figs. 5, 22.

Description. – Wright (1987).

Specimen examined. – ARGENTINA, La Rioja: Saladillo, 29° 18′ 40″ S 66° 53′ 56″ W, on sandy soil, *leg.* L. Papinutti & G. Rolón, 07 Apr 2012, FK 1205.

Comments. – This well-delimited species can be distinguished by its tubular peristome, membranous and more or less persistent exoperidium, and unusually large basidiospores. There are two other species with large basidiospores in Wright's (1987) monograph, *viz.*, *T. macrosporum* G. Cunn. and *T. utahense* Wright. The best difference of the first one is the exoperidium, being hyphal in *T. macrosporum* and membranous in *T. meridionale*. With regard to *T. utahense*, there are few reliable differences, mainly concerning the not projected peristome and the very pale stipe. All other dissimilarities noted by Wright (1987) have a broad overlap; for these reasons, we follow here Altés & Moreno (1999) who considered *T. utahense* to be a synonym of *T. meridionale*. This is the first record of this species for La Rioja.

Vascellum intermedium A. H. Sm., Bull. Mens. Soc. Linn. Lyon: 43. 1974. – Figs. 8, 23.

Description. – Kreisel (1993).

Specimens examined. – ARGENTINA, La Rioja: Miranda, 29° 20′ 51″ S 67° 42′ 22.16″ W, on sandy soil, *leg.* L. Papinutti & G. Rolón, 27 Mar 2008, BAFC 52196.

Description. – Basidiomata 6–19 mm in diam. × 5–9 mm high, globose to flattened, rhizomorph encrusted with a thick mass of soil particles, ostiole like an irregular hole; exoperidium yellowish white (10D4), glabrous, not encrusted, formed by minute verrucae becoming smaller towards the base of the basidioma and peeling off in age, especially deciduous in the surrounding area of the ostiole; endoperidium gray (10D5), papery; gleba yellowish brown (14F4); diaphragm papery, well delineated; subgleba cellular, dark olive-yellow (14A6). Spores 3.5–4.3 µm, globose, punctate, with central oil drop, remnants of sterigmata long and deciduous, leaving a short pedicel; eucapillitium absent; paracapillitium abundant, dichotomously ramified, septate, not pitted.

Comments. – Bates (2004) describes this species as occurring in conifer forests under *Pinus* or *Juniperus* and restricted to Arizona and Texas. Kreisel (1993) refers to it as occurring also in Texas, southern Slovakia and in xerothermic vegetation in Mongolia, suggesting a worldwide distribution. Our specimen is the first record for South America.

Occurrence of spore types according to habitat

A total of 37 anemophilous species from the present work and previous research (Domínguez de Toledo 1989, Dios *et al.* 2004, Kuhar *et al.* 2010) were analysed in relation to their spore ornamentation and habitats. The relative abundance of species with each spore type is shown in Fig. 24 revealing a similar pattern to that proposed by Kreisel & Al-Fatimi (2008), who suggest that anemophilous species with ornamented spores would be better adapted to relatively humid landscapes. They interprete the ornamentation as a "wa-

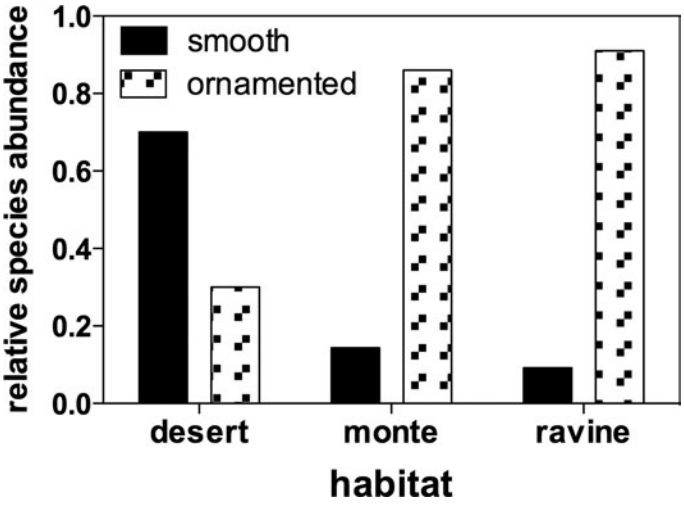


Fig. 24. Distribution of anemophilous species with smooth and ornamented spores recorded in present and previous works (Domínguez de Toledo 1989, Dios *et al.* 2004 and Kuhar *et al.* 2008).

ter repellent structure" that allows spore liberation in moistened environments. Although new data and species are needed to confirm the hypothesis that predicts supremacy of smooth-spored species over ornamented-spored species in desert habitats and vice versa as humidity increases, the hypothesis is borne out by currently available data. In our study there were strongly dominant smooth-spored species in Desert, such as *Podaxis pistillaris*, while in Monte and Ravine these species disappear completely and other species (*e.g. Battarrea phalloides*, *Geastrum fornicatum*, *Disciseda* spp., *Bovista* spp.) become dominant. Thus, these results suggest that performance of individual species in arid regions with heterogeneous landscapes is highly dependent on spore dispersion.

Acknowledgements

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