



Plant communities and soil phytolith assemblages relationship in native grasslands from southeastern Buenos Aires province, Argentina

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ABSTRACT

This study has compared the phytolith production and soil phytolith assemblages of two native grass communities typical in Argentina, namely the monospecific *Paspalum quadrifarium* community or “pajonal”, and the *Stipa-Piptochaetium* community or “flechillar”. Five sites – three of which had been unmanaged while other two had been submitted to fire and fire-grazing management activities – were selected for study. The results show that in these sites a) phytolith production of the plant communities differed due to their diverse floristic composition, b) it was possible to define the type of management or the type of community based on soil phytolith assemblages, c) there were differences between plant communities and soil phytolith assemblages. These results suggest that modern phytolith assemblages are composed not only of local and present vegetation but also of extralocal/regional and probably past vegetation. Hypotheses about the probable processes involved in phytolith incorporation to soil have emerged during the investigation.

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1. Introduction

In South America, temperate sub-humid grasslands are distributed along central-eastern Argentina, Uruguay and southern Brazil and they are referred to as the Rio de la Plata grasslands (Soriano et al., 1991). In Argentina, the Pampas sub region has been early modified since its European settlement (Soriano et al., 1991; Ghersa and Leon, 2001). The changes include the replacement of native vegetation by crops and pastures as well as settlements, both giving birth to an agricultural region of great economic importance in the country (Soriano et al., 1991; Ghersa and Leon, 2001). As a consequence, the native grasslands areas have been restricted to sectors where agricultural activities are impeded, for example by the presence of rocky outcrops and shallow soils.

Recent studies have identified two Pampean native grasslands: the *Paspalum quadrifarium* community or “pajonal” and *Stipa-Piptochaetium* community or “flechillar” growing on hills from Tandilia Range, in the province of Buenos Aires (Frangi, 1975; Herrera, 2007; Herrera and Littera, 2008). Both communities are of great ecological and biological importance due to their high biodiversity (especially the

Stipa-Piptochaetium community) and because they are a refuge for native fauna (Comparatore et al., 1996; Herrera, 2007). The knowledge of their presence in the Tandilia Range is quite new and elicits two questions: 1) Have both communities always been present in these sectors or have they arrived there as a consequence of the displacement by crops and pastures? 2) If these grasslands were not always in these sectors, which plant communities were dominant before? The answer to these questions would contribute to the knowledge of these native communities' history and distribution, and to the paleograsslands' history of this Argentine region.

Phytolith analyses have been widely applied to studies of Poaceae dominated communities, such as grasslands (Metcalf, 1960; Twiss et al., 1969; Fredlund and Tieszen, 1994; Alexandre et al., 1997; Strömberg, 2004). In Argentina, particularly in the province of Buenos Aires, numerous phytolith studies of quaternary sedimentary sequences, soils and archaeological sites have been completed (Osterrieth, 2000; Osterrieth et al., 2002; Zucol et al., 2002; Osterrieth, 2006; Osterrieth et al., in press). However, few studies have focused on the relationship between plant phytolith production and soil assemblages or to the processes involved in the formation of modern soil phytolith assemblages, information that is essential for the interpretation of the fossil phytolith assemblages.

The present article offers a comparative phytolith study of the *P. quadrifarium* and *Stipa-Piptochaetium* communities. The objective has been to describe and compare the phytolith assemblages of both communities and the top five cm of associated soils so as to provide a modern model of the phytolith production of these communities.

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Within this context we have studied unmanaged and managed (burned and grazed) sites, so as to compare the effect of agricultural management on soil phytolith assemblages. Since that the only dominant species in the “pajonal” is *P. quadrifarium*, we considered it to be an adequate case for a detailed analysis of the phytolith production and soil incorporation. For this reason and in an exploratory mode, we have also included the study of the phytolith production of other organs apart from the leaves of *P. quadrifarium* and the phytolith assemblage of organic horizons. Finally, this article provides some hypotheses about the processes involved in the formation of these modern soil phytolith assemblages based on geomorphologic and pedological features and the agricultural management in the area.

2. Study area

The study area is located between 37°19'S–59°15'W and 37°50'S–58°30'W, and is restricted to the low hills (less than 200 m.a.s.l.) from the Tandilia Range, Buenos Aires province, Argentina (Fig. 1). It is a mesothermic subhumid–humid area with null or little water deficiency and an annual rainfall of about 800 mm/year (Burgos and Vidal, 1951). The mean monthly temperatures for the warmest and coldest month are 23 and 13 °C, respectively (Soriano et al., 1991).

The hills are floristically characterized by the presence of the *P. quadrifarium* community and the *Stipa-Piptochaetium* community, which is represented by Stipoideae subfamily. The *P. quadrifarium* community is a monospecific community dominated by *P. quadrifarium*. The most abundant species developed in the *Stipa-Piptochaetium* community are *Piptochaetium bicolor* (Vahl) Desv., *Piptochaetium medium* (Speg.) M. A. Torres, *Piptochaetium hackelii* (Arech.) Parodi, *Stipa neesiana* Trin. et Rupr., *Stipa bonariensis* Henr. et Parodi, *Briza minor* Linnaeus, *Briza brizoides* (Lam.) O. Kuntze, *Bromus auleticus* Trin., *Bothriochloa laguroides* (D.C.) Pilger and *Sorghastrum pellitum* (Hack.) Parodi. (Herrera, 2007; Herrera and Laterra, 2008). There also are some shrubs such as *Eupatorium bupleurifolium* DC., *Baccharis rufesens* Spreng., *Margyricarpus pinnatus* (Lam.) O. K. and dycotiledons such as *Oxalis* L. spp., *Heliotropium amplexicaule* Vahl., *Adesmia bicolor* (Poir.)

DC., *Medicago lupulina* L. and *Ambrosia tenuifolia* Spreng. (Herrera, 2007; Herrera and Laterra, 2008). Due to the abundant rocky outcrops and the soil heterogeneity, these hills are not used for agricultural activities; however, some areas have been grazed, or subjected to winter burnings, which produce structural changes in the *P. quadrifarium* community and floristic ones in the *Stipa-Piptochaetium* community. The structural changes in the *P. quadrifarium* community include a lower height of *P. quadrifarium* specimens and a decrease of litter accumulation beneath tussocks. The floristic changes at *Stipa-Piptochaetium* community include an increment of *B. laguroides*, *Dactylis glomerata*, *Vulpia dertonensis*, *Carduus acanthoides* and *Cirsium vulgare* at grazed sites and the dominance of *Achillea millefolium* and *C. acanthoides* at burned sites (Herrera, 2007).

Soils have developed from the quaternary loess that covers the Paleozoic quartzites which constitute the Tandilia Range (INTA, 1989, 1991). The thickness of the loess deposited above quartzites was variable, due to the irregular microrelief of this rocky layer, and this has originated different types of soils within each hill. Typic Hapludolls and Argiudolls with 10–25 cm and 20–+70 cm of depth, respectively, predominate (INTA, 1989; Fernández Honaine, 2007). Both soil types are developed in all plant communities, being the organic horizon thickness the main difference. *P. quadrifarium* community soils have a 10–15 cm organic horizon thickness, while *Stipa-Piptochaetium* community soils have an organic horizon thickness less than 5 cm (Fernández Honaine, 2007). This is a consequence of the presence of *P. quadrifarium*, which is characterized by the large accumulation of dead standing biomass beneath tussocks.

3. Methods

3.1. Sampling sites

Five sites (C1, C2, C3, G and B) located along the Tandilia Range with similar geomorphologic and pedologic features but different agricultural management were selected for this study (Fig. 1). At each site, *P. quadrifarium* and *Stipa-Piptochaetium* communities were present.

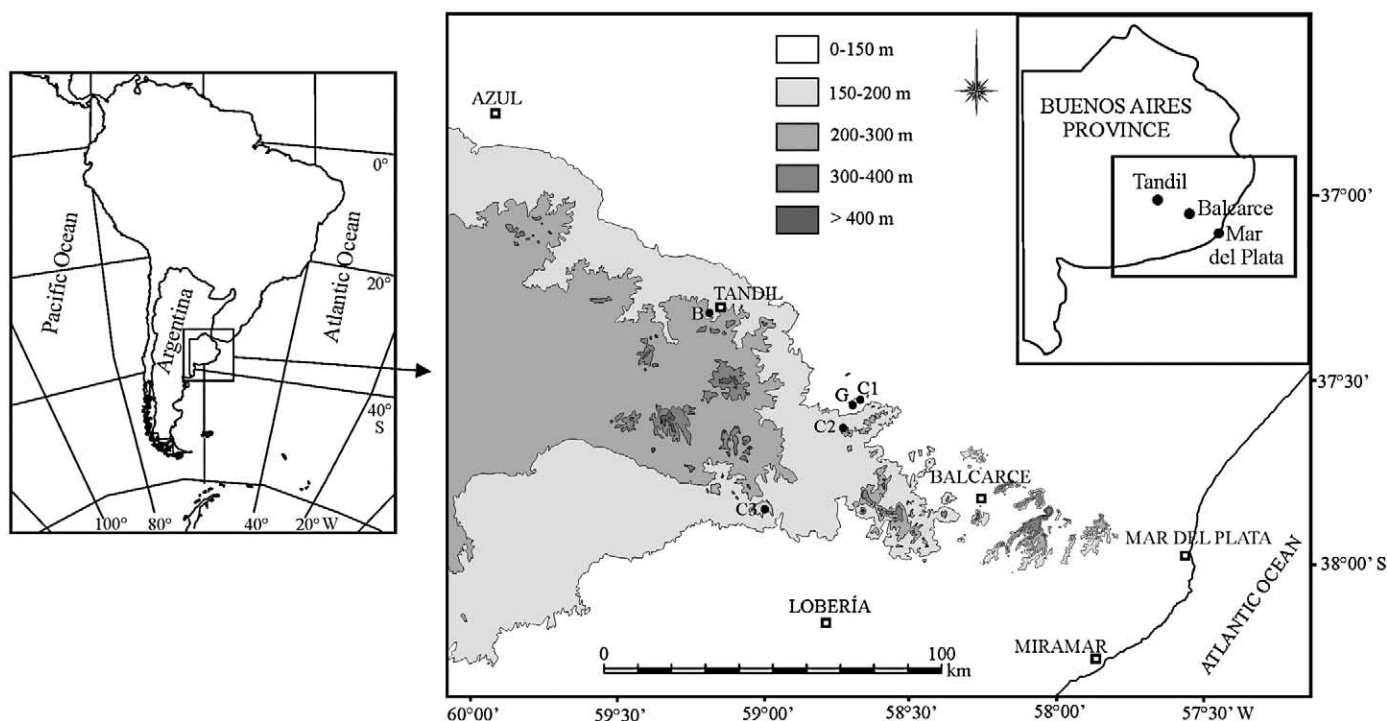


Fig. 1. Location of sampling sites along Tandilia Range, province of Buenos Aires, Argentina. C1, C2 and C3: non-management sites; G: grazed site; B: burned site.

Table 1

Species of each plant community selected for the study

Plant communities	Species (family or subfamily)	Location
<i>Paspalum quadrifarium</i> community	<i>Paspalum quadrifarium</i> Lam. (Pa)	All sites
<i>Stipa-Piptochaetium</i> community	<i>Achnatherum papposum</i> (Nees) Barkworth (= <i>Stipa papposa</i> Nees) (St) <i>Bothriochloa laguroides</i> (D.C.) Pilger (Pa) <i>Briza subaristata</i> Lam. (Po) <i>Bromus auleticus</i> Trin. (Po) <i>Bromus catharticus</i> Vahl. (Po) <i>Dactylis glomerata</i> L. (Po) <i>Danthonia montevidensis</i> DC. et Lam. (Ar) <i>Festuca arundinacea</i> Schreb. (Po) <i>Hordeum pusillum</i> Nutt. (Po) <i>Nasella neesiana</i> (Trin. et Rupr.) Backworth (= <i>Stipa neesiana</i> Trin. et Rupr.) (St) <i>Nasella trichotoma</i> (Nees.) Hack. ex Arechav. (= <i>Stipa trichotoma</i> Nees) (St) <i>Melica brasiliensis</i> Ard. (Po) <i>Piptochaetium bicolor</i> (Vahl) Desv. (St) <i>Piptochaetium hackelii</i> (Arech.) Parodi (St) <i>Piptochaetium lasianthum</i> Gris. (St) <i>Piptochaetium medium</i> (Speg.) M. A. Torres (St) <i>Sorghastrum pellitum</i> (Hack.) Parodi (Pa) <i>Vulpia dertonensis</i> (All.) Gola. (Po)	C1, C2, C3
<i>Stipa-Piptochaetium</i> community at grazed site	<i>Bothriochloa laguroides</i> (D.C.) Pilger (Pa) <i>Dactylis glomerata</i> L. (Po) <i>Vulpia dertonensis</i> (All.) Gola. (Po) <i>Carduus acanthoides</i> L. (As) <i>Cirsium vulgare</i> (Savi) Ten. (As)	Grazed sites (G)
<i>Stipa-Piptochaetium</i> community at burned site	<i>Achillea millefolium</i> L. (As) <i>Carduus acanthoides</i> L. (As)	Burned sites (B)

As: Asteraceae family; subfamilies according to Watson and Dallwitz (1992);
Ar: Arundinoideae, Pa: Panicoideae, Po: Pooideae, St: Stipoideae.

Sites C1, C2 and C3 had been unmanaged for many years (Herrera, 2007; Herrera and Lateral, 2008). C1 and C3 had not been managed for at least 30 years, while C2 had not been managed for approximately five years (Herrera, 2007; Herrera and Lateral, 2008). Poaceae species that characterize the communities in these three sites are described in Table 1. There were no great differences in vegetation characteristics between sites, but some special features can be mentioned for site C3. Shrubs of “curro” (*Colletia paradoxa*) and a greater height of “flechillar”

Table 3

Phytolith morphotypes used in this study and the names according to the ICPN 1.0 (Madella et al., 2005)

	Phytolith morphotypes used in this study	Names according to ICPN
	Articulated forms ^a	Silica skeletons
Isolated forms	Crescent moon ^b	Reniform trapeziform
	Saddle ^b	Saddle
	Cross ^b	Cross
	Simple lobate dumb-bell ^c	Bilobate convex end short cell
	Panoid dumb-bell ^c	Bilobate flat/concave end short cell
	<i>Stipa</i> type dumb-bell ^c	Bilobate trapeziform concave end short cell
	Irregular dumb-bell ^b	Cylindrical polylobate
	Elongate/rectangular ^b	Parallelepipedal/elongate
	Oblong and crenate	Trapeziform sinuate
	Fan/polyhedral ^b	Cuneiform/parallelepipedal bulliform cell
	Point shaped ^b	Hooks, prickles and macrohairs
	Equidimensional and flat cone ^d	Rondel
	Jigsaw (puzzle forms) ^e	Tabular lobate
	Epidermal polygonal ^e	Tabular polygonal psilate epidermal cell

^a *sensu* Zucol (1996).^b *sensu* Twiss (1992).^c *sensu* Fredlund and Tieszen (1994).^d *sensu* Bertoldi de Pomar (1971).^e *sensu* Bozarth (1992).

species were observed (1.5 m vs. 1.2 m observed in sites C1 and C2) (Fernández Honaine, 2007; Herrera, 2007). Sites G and B had been subjected to management activities: range management at G and winter burning and grazing at B. These activities modified the *Stipa-Piptochaetium* community and new species have begun to dominate. The Asteraceae species and annual grasses representative of these sites are described in Table 1.

3.2. Soil sampling and phytolith extraction and counting

The soil sampling was conducted at all sites and in each plant community. Composite samples (consisting of five subsamples of 0.4×0.4 m²) of the top 5 cm of the A horizon were collected in each plant community at each site; ten in all (Table 2).

Table 2

Soil samples information and phytolith counting

Soil samples labels	Geographical coordinates	Plant community	Management practice	Grams collected	Counting (number of particles)					
					Phytoliths	Diatoms	Sponge spicules	Cryptophyceae stomatocysts	Volcanic glass	Total particles
C1p	37°34'29.2"S 58°41'4.6"W	<i>P. quadrifarium</i> community	–	20	522	1		7	13	543
C1f	37°34'28.6"S 58°41'2.7"W	<i>Stipa-Piptochaetium</i> community	–	20	460			4		464
C2p	37°38'9.5"S 58°43'14.7"W	<i>P. quadrifarium</i> community	–	20	477		3	1	14	465
C2f	37°38'9.1"S 58°43'13.6"W	<i>Stipa-Piptochaetium</i> community	–	20	535	1		3	15	554
C3p	37°47'34.3"S 58°58'6.3"W	<i>P. quadrifarium</i> community	–	20	536	4		5	12	557
C3f	37°47'33.9"S 58°58'6"W	<i>Stipa-Piptochaetium</i> community	–	20	508		1		15	524
Gp	37°34'41.6"S 58°41'18.1"W	<i>P. quadrifarium</i> community	Grazing	20	517	1		5	2	525
Gf	37°34'39"S 58°41'17"W	<i>Stipa-Piptochaetium</i> community	Grazing	20	497			2	4	503
Bp	37°19'44"S 59°11'20.2"W	<i>P. quadrifarium</i> community	Winter burnings and grazing	20	523			2	11	536
Bf	37°19'43"S 59°11'21.6"W	<i>Stipa-Piptochaetium</i> community	Winter burnings and grazing	20	485		2	2	17	506

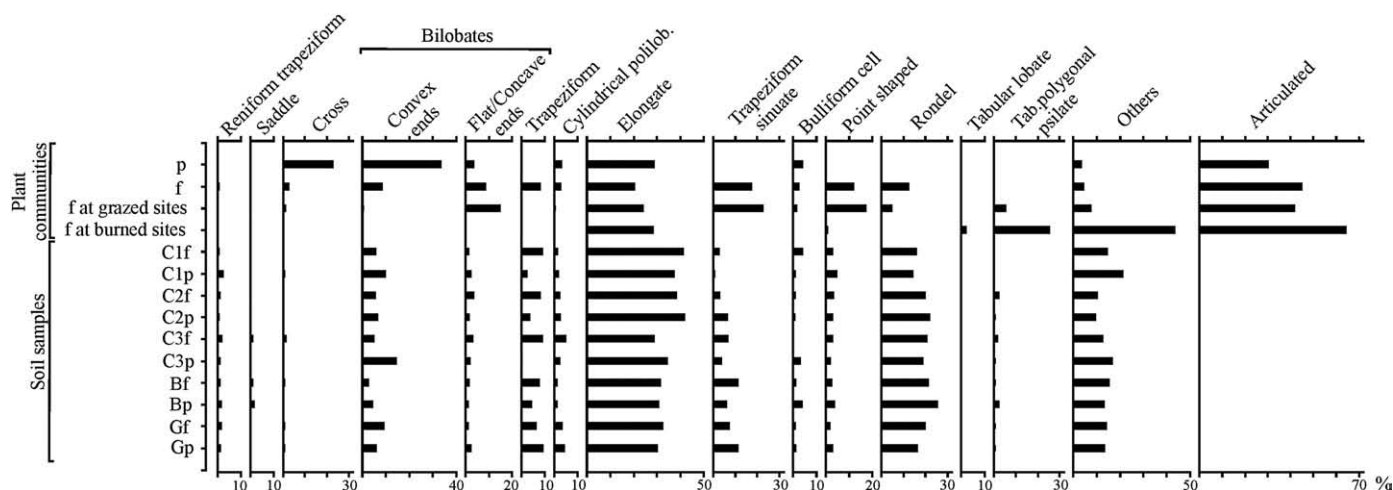


Fig. 2. Relative frequencies of phytolith morphotypes in plant communities and soil samples. C1, C2 and C3: non-management sites; B: burned site; G: grazed site; f: *Stipa-Piptochaetium* community; p: *Paspalum quadrifarium* community.

Four grams from each composite soil sample were analyzed. Carbonates (with HCl 10%), organic matter (with heat and H₂O₂ 30%), and clays (with Calgon 0.5% and centrifugation at 1000 rpm for 3 min) were eliminated. The amorphous silica fraction of all samples was separated by density with Sodium polytungstate (2.3 g/cm³ density) according to Madella et al. (1998).

At three sites (C2, C3 and G) the organic horizon from *P. quadrifarium* community soils was also collected. The samples were subdivided in O_i and O_e, according to the decomposition degree, and phytoliths were extracted in two different ways. O_i horizon was ignited, following the Labouriau calcination technique (Labouriau, 1983). O_e horizon was subject to the same treatment described for horizon A samples, after passing the sample through a 1 mm sieve, so as to discard larger plant fragments.

The amorphous silica fraction of soil samples was mounted with oil immersion and observed with a Leitz Wetzlar D 35780 microscope at ×400 magnification. At least 450 particles (including phytoliths, volcanic glass, sponge spicules, Cryosphyceae stomatocysts and diatoms) were counted. Phytolith morphotypes were classified following the schemas of Bertoldi de Pomar (1971), Bozarth (1992), Twiss (1992), Fredlund and Tieszen (1994) and Zucol (1996) (Table 3). Phytolith names follow the ICPN nomenclature (Madella et al., 2005; Table 3).

3.3. Phytolith assemblages of plant communities

Phytolith descriptions of plant communities were based on previous data obtained by the authors (Fernández Honaine et al., 2005; 2006). At least five individuals of the most abundant and representative species of each community were selected (Table 1) and leaf phytoliths were extracted following Labouriau calcination technique (Labouriau, 1983; Fernández Honaine et al., 2006). Phytoliths from culms, inflorescences and roots were also extracted from *P. quadrifarium* individuals, following the same technique

(Labouriau, 1983; Fernández Honaine et al., 2005). The relative frequencies of the phytolith morphotypes of each community were calculated as the average of the relative frequencies of the phytolith morphotypes of the species of each community.

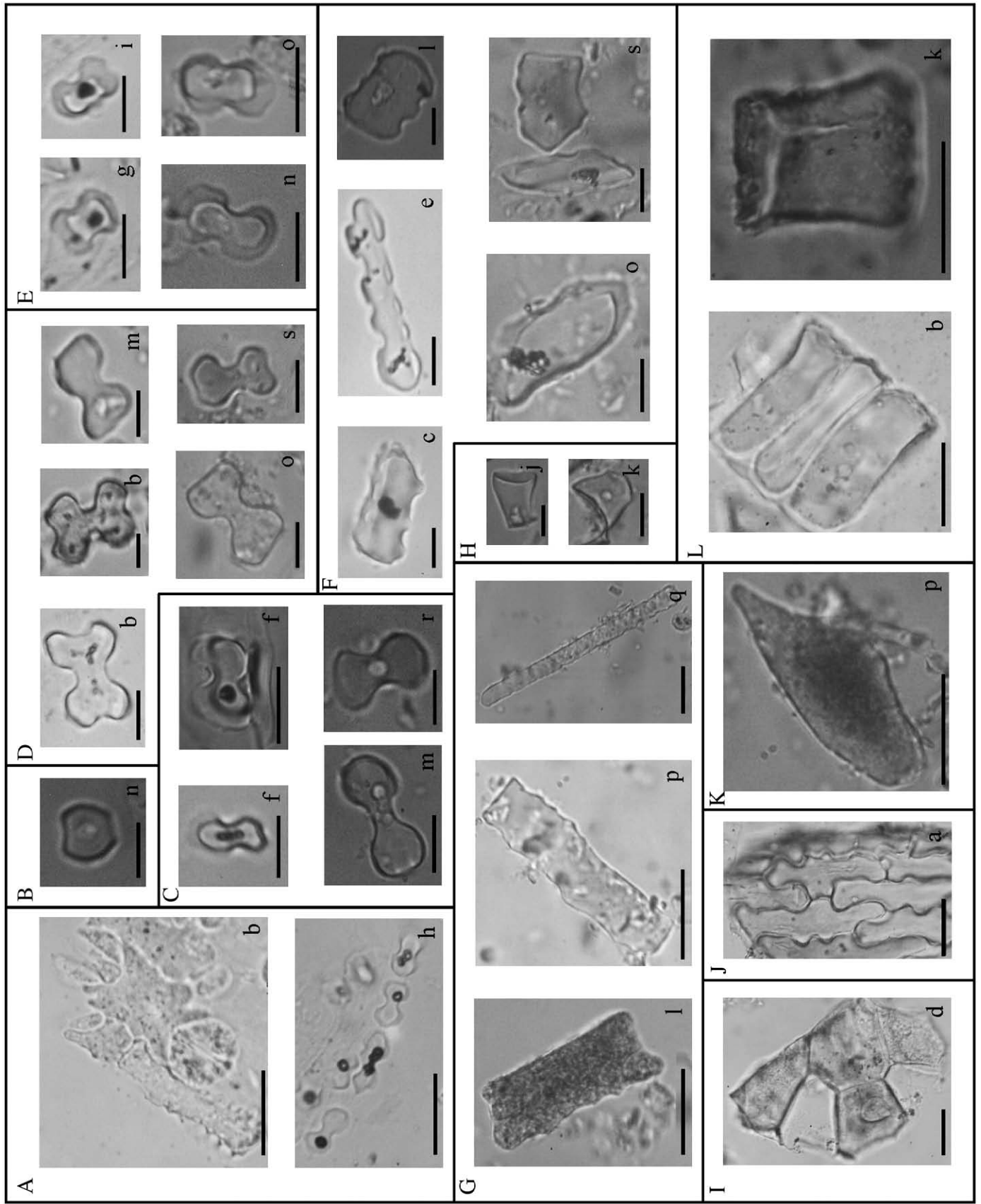
3.4. Data analyses

Cluster analyses were carried out with the purpose of analysing the relationship between the plant communities and soil phytolith assemblages. Morisita association index and unweighted pair-group method, arithmetic average linkage (UPGMA) were used. To establish the morphotype importance in the segregation of samples, principal component analysis (PCA) was performed, on the basis of a variance-covariance matrix. In both analyses, only the relative frequencies of the isolated morphotypes were used; they were recalculated without including the silica skeletons morphotypes in the total sum.

4. Results

The comparative analysis of the phytolith assemblages showed clear differences between *P. quadrifarium* and *Stipa-Piptochaetium* communities (Fig. 2). *P. quadrifarium* community produced bilobate convex end short cell (33.4%) (Fig. 3Cf), crosses (23%) and elongate phytoliths (28.8%). The phytolith assemblages of *Stipa-Piptochaetium* community was characterized by Stipoideae phytoliths such as bilobate trapeziform concave end short cell (8.1%) (Fig. 3Eg, Ei), Pooideae phytoliths such as trapeziform sinuate phytoliths (17.3%) (Fig. 3Fc, Fe) and rondels (12.3%), and Panicoideae phytoliths such as bilobate flat/concave end short cell (8.4%) (Fig. 3Db). The phytolith assemblage of the *Stipa-Piptochaetium* community at grazed sites was characterized by the presence of Asteraceae phytoliths such as tabular polygonal psilate epidermal cell (5.3%) (Fig. 3I) and Pooideae phytoliths, such as trapeziform sinuate phytoliths (22.6%). Lastly, the

Fig. 3. A. Silica skeletons. B. Saddle. C. Bilobate convex end short cell. D. Bilobate flat/concave end short cell. E. Bilobate trapeziform concave end short cell. F. Trapeziform sinuate. G. Elongate. H. Rondel. I. Tabular polygonal psilate epidermal cell articulated. J. Tabular lobate articulated. K. Point shaped. L. Cuneiform/Parallelipedal bulliform cell articulated and isolated. a–i: plant morphotypes; j–r: A horizon soil samples morphotypes; s: O_e horizon soil samples morphotypes. a. *Achillea millefolium*. b. *Bothriochloa laguroides*. c. *Bromus auleticus*. d. *Carduus acanthoides*. e. *Dactylis glomerata*. f. *Paspalum quadrifarium*. g. *Piptochaetium hackelii*. h. *Stipa neesiana*. i. *Stipa trichotoma*. j. site C1, *Stipa-Piptochaetium* community. k. site C1, *P. quadrifarium* community. l. site C2, *Stipa-Piptochaetium* community. m. site C2, *P. quadrifarium* community. n. site C3, *Stipa-Piptochaetium* community. o. site P, *Stipa-Piptochaetium* community. p. site P, *P. quadrifarium* community. q. site Q, *Stipa-Piptochaetium* community. r. site Q, *P. quadrifarium* community. s. site C3, *P. quadrifarium* community. Scale bar figures A, G, I–L = 25 μm; figures B–F, H = 10 μm.



phytolith assemblage of the *Stipa-Piptochaetium* community at burned sites differed by the presence of Asteraceae phytoliths: tabular lobate phytoliths (2.2%) and tabular polygonal psilate epidermal cell (25.5%) (Fig. 3I, J).

The dominant phytolith morphotypes in soil samples of all plant communities were elongate phytoliths and rondels (Fig. 2, 3G, H). The absence of silica skeletons (Fig. 3A) and Asteraceae morphotypes, like tabular lobate and tabular polygonal psilate epidermal cell phytoliths (Fig. 3I, J) was noteworthy, especially at managed site soils. At all sites, the soil phytolith assemblages under *P. quadrifarium* community were mainly characterized by bilobate convex end short cell (Fig. 3C), while bilobate trapeziform concave end short cell (Fig. 3E) differentiated the soils of the *Stipa-Piptochaetium* communities. Finally, the abundance of trapeziform sinuate phytoliths (Fig. 3F) was higher in managed site soils (B and G) than in non-managed site soils (C1, C2 and C3).

Multivariate analyses showed a clear differentiation of plant communities and soil phytolith assemblages (Figs. 4 and 5). Within soil samples, cluster analysis revealed two groups (Fig. 4). The first one was composed of the managed sites (G and B) and the *Stipa-Piptochaetium* community C3 site (C3f). The second group was composed of *P. quadrifarium* community C3 site (C3p), site C1 (C1f and C1p) and site C2 (C2f and C2p).

The first two axes of the PCA where plant communities and soil samples were included (Fig. 5A), developed three groups. The first one constituted by soil samples, the second group constituted by *P. quadrifarium* community; the third group included the rest of plant communities. Axis 1 (47% of total variance) from PCA of soil assemblages (Fig. 5B) separated managed sites (G and B) from non-managed sites (C1, C2 and C3). The phytolith morphotypes that mainly contributed to this differentiation were elongate, trapeziform sinuate phytoliths and bilobate convex end short cell. Meanwhile axis 2 (22% of total variance) separated *P. quadrifarium* community soils from the other soil assemblages. The phytolith morphotypes that mainly contribute to this differentiation were bilobate convex end short cell, bilobate trapeziform concave end short cell and elongate phytoliths.

The phytolith analysis carried out on *P. quadrifarium* community and the associated soil, which included the organic horizon and other organs of the species, showed similar results. Even though *P. quadrifarium* is almost the only species that contribute to the phytolith assemblage of the community, soil phytolith assemblage showed some qualitative and quantitative differences to the phyto-

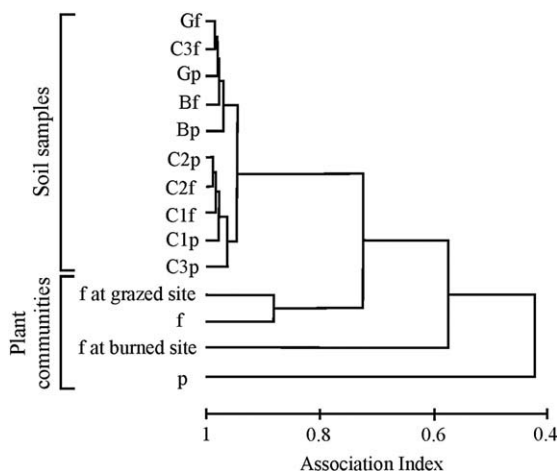


Fig. 4. Dendrogram showing plant communities and soil samples grouping based on their phytolith assemblage. C1, C2 and C3: non-management sites; B: burned site; G: grazed site; f: *Stipa-Piptochaetium* community; p: *Paspalum quadrifarium* community.

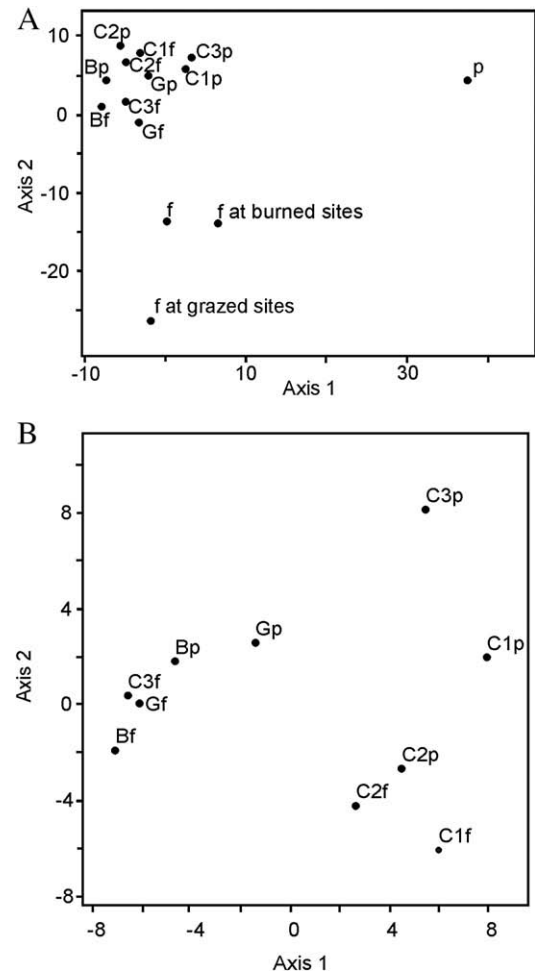


Fig. 5. A) Principal components analysis of plant communities and soil samples based on their phytolith assemblages. The first three axes amounted to 89.4% of the total variance (39.6% for axis 1, 31.2% for axis 2, and 21.2% for axis 3). B) Principal components analysis of soil samples based on their phytolith assemblages. C1, C2 and C3: non-management sites; B: burned site; G: grazed site; f: *Stipa-Piptochaetium* community; p: *Paspalum quadrifarium* community.

liths of this species (Figs. 6 and 7). The dendrogram (Fig. 7) clearly shows the separation between the phytolith assemblages of plant organs (except leaves) and A/O_e horizons and the strong association between the assemblages of leaves and O_i horizon.

5. Discussion

A previous study has shown that the main species of the *P. quadrifarium* and *Stipa-Piptochaetium* communities produced distinct phytolith assemblages (Fernández Honaine et al., 2006), and as a consequence the dominant phytolith morphotypes of the plant communities assemblages also differed. The results corroborate the phytolith assemblage usefulness in the differentiation of plant communities and underscore the taxonomic and palaeobotanical importance of the silicification of short cells (bilobates, rondels and trapeziform sinuate phytoliths), as described by other authors (Twiss et al., 1969, Mulholland, 1989, Fredlund and Tieszen, 1994).

Elongate phytoliths – whose taxonomic value is poor because they are produced by numerous families – and the rondels – which have been described for Poaceae subfamilies such as Pooideae and Stipoideae – were dominant in soil assemblages. However, there were variations in the abundance of grass phytoliths derived from silicifications of short cells, such as trapeziform sinuate and bilobates.

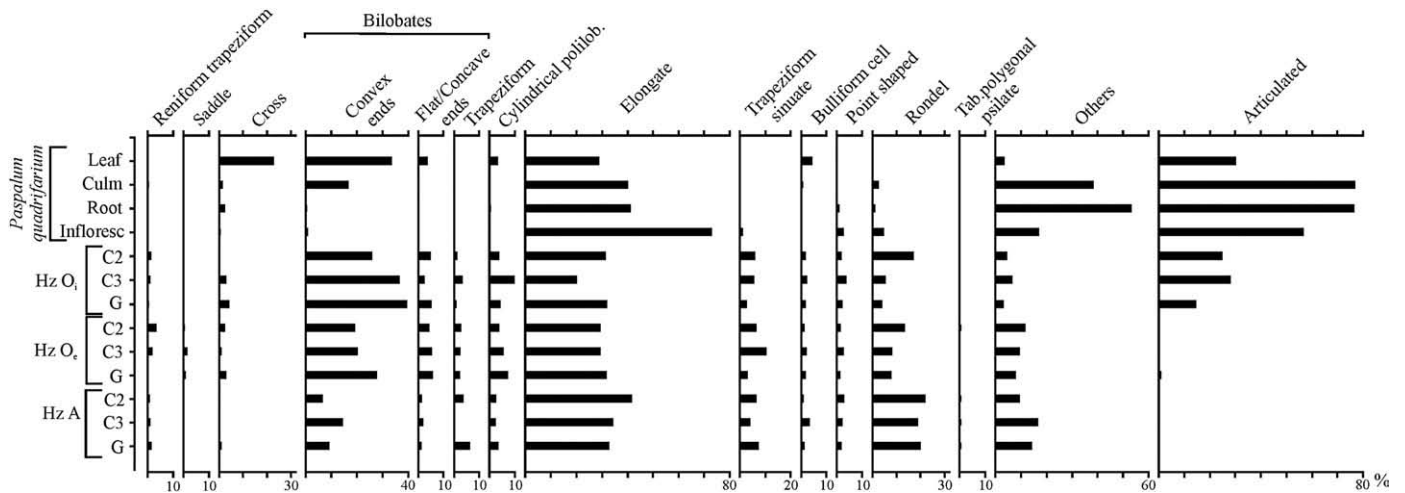


Fig. 6. Relative frequency of phytolith morphotypes in *P. quadrifarium* (extracted from Fernández Honaine et al., 2005, 2006) and soils associated. Infloresc: inflorescence; Hz: horizon; C2 and C3: non-management sites; G: grazed site.

From these variations, we were able to differentiate the phytolith assemblages of soils with different type of management or plant community.

Although the major component of soil phytolith assemblage derived from local vegetation (as it is shown in morphotype frequencies, Fig. 2), plant and soil assemblages showed some differences in their phytolith composition. Some morphotypes (for example, silica skeletons or Asteraceae phytoliths) produced by the dominant species, were found at a low percentage or absent in soil assemblages. Qualitative or quantitative differences in silicification process, or dissolution or physical fragmentation of phytoliths may explain these results (Thorn, 2004; Hodson et al., 2005). The lower silicification degree of Asteraceae phytoliths conditioned their preservation and prevented their presence in soils of the managed sites (G and B sites). Instead, phytoliths derived from the grasses growing along with Asteraceae species were dominant in these soils. These results showed that grasses could be overrepresented in phytolith record, due to the greater production and higher resistance to degradation of their phytoliths, even though they were not the dominant species. Silica skeletons are easily disarticulated, so they are

usually observed in soils with specific preservation conditions, such as in archaeological sites (Osterrieth et al., 2002; Zucol et al., 2002) or in active dune environments where superficial soil horizons are buried by dune overlapping (Osterrieth and Fernández Honaine, 2007).

Phytoliths from the organic horizon were closely related to plant phytolith production, especially in the O_i horizon. Instead, phytolith assemblages of A horizon (0–5 cm depth) contained low percentages of morphotypes produced by non-local vegetation, as was shown in the case study of the *P. quadrifarium* community. Two possible explanations can account for this. They could be consequence of the *in situ* incorporation of phytoliths from annual grasses that occasionally grow with *P. quadrifarium*, and which were not taken into account in the analysis, such as *D. glomerata*, *B. auleticus* and *Phalaris augusta* (Lattera, P., personal communication, 2006), or they could be derived from adjacent sites by different processes, such as eolian transport and fire-eolian transport (Fredlund and Tieszen, 1994). The fact that the study area is elevated and exposed to wind action and the numerous antecedents of grasslands burns—due to either the agricultural practice to increase forage quality or to a non-intentional event during dry and warm seasons (Lattera et al., 1994, 1998; Ghersa and Leon, 2001)—demonstrates that the above mention process are possible. Grazing management can also alter phytolith assemblage of soils, since animal feces can be a source of extralocal phytoliths (Wallis, 2001). Also, the irregular microrelief of the study area, a consequence of the rocky outcrops, may cause the movement of the particles by runoff.

Finally, the results show that soil phytolith assemblage is composed by phytoliths produced not only by local and current vegetation, but also by extralocal and regional. However, the major components of the assemblages are derived from local and current plants, especially in O horizons. These aspects should be taken into account in the interpretation of phytolith assemblages of fossil record.

6. Conclusions

The present study is one of the first contributions to the comprehension of the phytolith production, deposition and incorporation processes in modern soils from Argentina native grasslands, and particularly from the province of Buenos Aires. This information is crucial for the interpretation of fossil phytolith records in the region and for the understanding of the history and distribution of native grasslands of Argentina.

The results demonstrate that the plant communities can be characterized by their phytolith assemblage, due to their diverse

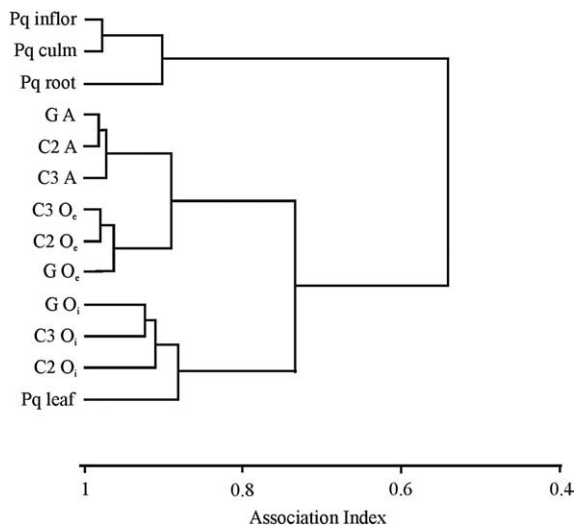


Fig. 7. Dendrogram showing *Paspalum quadrifarium* organs (Pq leaf, Pq root, Pq culm, Pq inflor) and soil samples grouping based on their phytolith assemblage. Inflor: inflorescence; C2 and C3: non-management sites; G: grazed site; A, O_e and O_i: soil horizons.

floristic composition. Differences in the type of plant community or type of management were reflected in the phytolith assemblages of the top five cm of the soils. The phytoliths originated from short cell silicifications of grass species (bilobates and trapeziform sinuate phytoliths) were responsible for this differentiation. However, we emphasize the importance in evaluating and considering the other phytolith morphotypes, since they complement the quantitative and qualitative definition of the assemblages.

Differences between current plant communities and soil phytolith assemblages allowed us to consider an important aspect in relation to modern analogs used on past communities interpretations. Organic horizon, especially O_i horizon, mainly represents present-day vegetation. Soil phytolith assemblage (0–5 cm) shows not only local and current vegetation, but also extralocal and/or recent past vegetation.

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