Phytotaxa 313 (1): 023–042
http://www.mapress.com/j/pt/

Article

ISSN 1179-3155 (print edition)
PHYTOTAXA
ISSN 1179-3163 (online edition)

https://doi.org/10.11646/phytotaxa.313.1.2

Geographic variation of *Serjania perulacea* (Paullinieae, Sapindaceae) and description of two new varieties

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Abstract

We assessed the morphological diversity of *Serjania perulacea* using multivariate analyses (principal coordinates and component analysis) of quantitative and qualitative morphological leaf traits. We also investigated the effect of local environmental conditions on the distribution of the different phenotypes. Our results indicate that *S. perulacea* consists of three varieties, which are restricted to specific geographic areas with distinct environmental conditions. The two new varieties *S. perulacea* var. *krapovickasii* and *S. perulacea* var. *chacoensis* are described here and a lectotype for the autonymic variety is designated. An identification key, illustrations and distribution maps for all three varieties are also provided.

Keywords: Leaf traits, Morphological variation, Multivariate Analysis, Niche modelling, Taxonomy

Introduction

Sapindaceae *s.str.* is a moderately large family of trees, shrubs, and lianas that comprises about 140 genera and ca. 1800 species, most of them with a tropical to subtropical distribution. However, some genera extend their distribution to temperate regions of Asia and North America, with the greatest diversity found in tropical Southeast Asia. In this study, we follow Radlkofer (1931)'s delimitation of the family which has been recently reinforced by Buerki *et al.* (2010). Radlkofer (1931) structured the family into 14 tribes, of which Paullinieae is the only tribe with climbing species. This tribe is a monophyletic group (Harrington *et al.* 2005, Buerki *et al.* 2009). Based on a molecular analysis Acevedo-Rodríguez *et al.* (2017) placed the tribe Paullinieae in the supertribe Paulliniodae and included in it the genera *Cardiospermum* Linnaeus, *Lophostigma* Radlkofer, *Paullinia* Linnaeus, *Serjania* Miller, *Thinouia* Triana & Planchon and *Urvillea* Kunth.

Serjania is a Neotropical genus of monoecious climbing shrubs with compound leaves, schizocarpic fruits with three samara-like mericarps, with the locule located in the distal portion thereof, or in rare cases with dehiscent fruits. The genus is widely distributed in the American continent, from southern United States to central Argentina and comprises about 230 species (Ferrucci & Acevedo-Rodríguez 2005, Ferrucci & Somner 2010, Ferrucci & Coulleri 2013). The most important contribution to the taxonomy of *Serjania* was made by Radlkofer (1874, 1875, 1931) who published the first synopsis for the genus (Radlkofer 1874), and later a monograph (Radlkofer 1875). In both studies, he grouped species of *Serjania* into 12 sections based on their reproductive and vegetative features. In Das Pflanzenreich, Radlkofer (1931) presented a worldwide monograph of the Sapindaceae family and he recognized 200 species of *Serjania*, 147 of which were of his authorship and nine new combinations. Later on, Acevedo-Rodríguez (1993) reduced the 12 sections to five and established a new one, sect. *Confertiflora* based primarily on fruit and seed characters.

Serjania perulacea Radlkofer (1874: 11) is a morphologically variable species mainly in vegetative characters such leaf blade dissection, shape of the terminal leaflet, leaflet apex, margin and indument. The distribution of this species covers southern South America, from Bolivia, to northern Argentina, Paraguay and Brazil (Central-west and Southeast regions). Across its distribution, populations of *S. perulacea* exhibit differences mainly in foliar morphological traits. Our field observations and study of specimens at the CTES herbarium suggest that populations with the same phenotypes are restricted to specific geographical regions. However, none of the descriptions prepared by Radlkofer

Accepted by Carlos Lehnebach: 16 Jun. 2017; published: 11 Jul. 2017

(1874, 1875) acknowledges this variation. It is likely that Radlkofer did not have access to many specimens of *S. perulacea* or these were all from the same geographical region.

The morphological variability observed in *S. perulacea* could indicate an active process of diversification. This scenario offers the possibility to study and identify the relative importance of evolutionary forces that either promote or prevent differentiation between populations by using different methodological approaches. The first step towards this direction is the analysis of the morphological variation. This approach can help us to understand how pleiotropic process, disequilibrium linkage, the environment, genetic drift and natural selection can generate trait variation within a species (Armbruster 1991; Endler 1995).

This study aims to analyze the morphological variation of *S. perulacea* across its geographical distribution using morphological data from multiple accessions of *S. perulacea* and multivariate analyses. Additionally, by conducting a multivariate analysis based of bioclimatic variables, we investigate whether climatic conditions influence the occurrence of each phenotype of *S. perulacea* to a determined area.

Materials and Methods

Plant material:—One hundred and forty-four specimens of *S. perulacea* from across its entire distribution were analyzed (Table 1). Biogeographically, the distribution of *S. perulacea* comprises the Chaco, Cerrado, Brazilian Atlantic Forest and Parana Forest (Morrone, 2006). In Argentina, it occurs in the provinces of Chaco, Corrientes, Formosa, Jujuy, Misiones and Salta. In Bolivia, it is found in the departments of Chuquisaca, Santa Cruz and Tarija. In Brazil it is found in the states of Goiás, Mato Grosso, Mato Grosso do Sul, São Paulo and Minas Gerais, and in Paraguay in the departments of Alto Paraguay, Amambay, Central, Concepción, Cordillera, Guairá, Itapúa, Misiones, Ñeembucú, Paraguarí, Presidente Hayes and San Pedro.

All specimens studied here were deposited in the herbarium of the Instituto de Botánica del Nordeste (CTES). Herbaria acronyms along the text follow Thiers (2017, continuously updated). We also studied digital images of the syntype specimens cited in Radlkofer (1875)'s monograph available from JSTOR Global Plants Initiative website (http://plants.jstor.org/, accessed 2016).

Morphological analysis:—We observed and measured two quantitative and five qualitative traits. The quantitative traits were length and width of the terminal leaflet. Qualitative traits were scored and coded as: leaf blade dissection (1 = imparipinnate, 2-jugate, the lower jugae 3-foliolate; 2 = imparipinnate, 2–3-jugate, the lower jugae 3–5-foliolate); terminal leaflet shape (1 = narrow ovate; 2 = ovate; 3 = widely ovate; 4 = obovate or widely obovate), apex of the terminal leaflet (1 = acute, 2 = obtuse, 3 = retuse), leaflet margin (1 = dentate-serrate, inconspicuous obtuse teeth; 2 = dentate-serrate, acute teeth; 3 = inciso-dentate); and indumentum (1 = glabrous, 2= ochraceous-pubescent).

We treated each individual (i.e. specimen) as an independent operational taxonomic unit (OTU) in the multivariate statistical test. A data matrix of seven variables and 144 OTUs was constructed (Table 1). The Gower's index, which allows the use of combined quantitative and qualitative data, was used as a dissimilarity measure between the populations. To assess morphological variation between populations of *S. perulacea* we conducted a principal coordinate analysis (PCoA). In addition, a principal component analysis (PCA) was used to identify which morphological variable displays the most variation among the specimens in relation to the analyzed variables. The software INFOSTAT 2011p (Di Rienzo *et al.* 2011) was used to perform all statistical analyses.

Geographical distribution:—Species distribution was obtained by mapping the collection locality details for each of the 144 specimens studied. Only some specimens (37%) had already georeferenced locality data. For the remaining specimens (63%) the geographical data were obtained using Google Earth 6.0 (http://www.google.com/earth/index.html). Maps were designed with DIVA-Gis 7.5.0.0 (Hijmans *et al.* 2004).

To assess the potential effect of the climatic variables in the distribution of each morphotype and the potential adaptive significance of each phenotypes, we extracted 19 bioclimatic variables from the WorldClim database (Hijmans *et al.* 2013) for each of the specimen listed in Table 2. These data are derive from the monthly temperature and rainfall values with a spatial resolution of 2.5 arc-minutes (5 km^2). A PCA was used to identify which climatic variables are linked to the morphological variation observed in this species. The PCA was performed with the software INFOSTAT 2011p (Di Rienzo *et al.* 2011). In addition, we used DIVA-Gis 7.5.0.0 for niche modelling taking into account the bioclimatic variables mentioned above.

TABLE 1. Data matrix with the 144 samples. Traits (acronyms and codes) are shown as: LBD= Leaf Blade dissection (1 = imparipinnate, 2-jugate, the lower jugae 3-foliolate; 2= imparipinnate, 2–3-jugate, the lower jugae 3–5-foliolate); STL = Shape of the Terminal leaflet (1 = narrow-ovate; 2 = ovate; 3 = wide ovate; 4 = obovate or wide obovate); LTL = Length of terminal leaflet (in cm); WTL = Width of the terminal leaflet (in cm); ATL = Apex of terminal leaflet = (1 = acute, 2 = obtuse, 3 = retuse); MTL = Margin of the terminal leaflet margin (1=dentate-serrate, inconspicuous obtuse teeth; 2 = dentate-serrate, acute teeth; 3 = inciso-dentate); Indument (1 = glabrous, 2 = ochraceus-pubescent).

Sample ID	Collector and Number	Country	LBD	STL	LTL	WTL	ATL	MTL	Indument
1	Schinini, A & Vanni, R.O. 15816	Argentina	2	1	7.4	3	1	1	1
2	Vanni, R.O. 3044	Argentina	2	1	3.3	1.7	1	1	1
3	Ferrucci, M.S. 30	Argentina	2	1	7.1	3	1	1	1
4	Tressens, S.G. *et al.* 3834	Argentina	2	1	5.1	2.4	1	1	1
5	Quarin, C. & Schinini A. 1277	Argentina	2	1	2.7	1	1	1	1
6	Pedersen, T.M. 9213	Argentina	2	2	5.5	3	1	1	1
7	Tressens, S.G. *et al.* 3775	Argentina	2	1	4.3	1.9	1	1	1
8	Arbo, M.M. *et al.* 2341	Argentina	2	1	4.4	2	1	1	1
9	Llamas, Q. 27378	Argentina	2	1	6.2	2.3	1	1	1
10	Tressens, S.G. *et al.* 2624	Argentina	2	1	8.5	3.6	1	1	1
11	Schinini, A. 11589	Argentina	2	1	5.5	2.4	1	1	1
12	Schinini, A. & Cristóbal C.L. 13637	Argentina	2	1	4.6	1.8	1	1	1
13	Schinini, A. *et al.* 6880	Argentina	2	1	3.3	1.4	1	1	1
14	Ferrucci, M.S. 29	Argentina	2	1	2.2	0.6	1	1	1
15	Tressens, S.G. *et al.* 771	Argentina	2	1	4.5	1.4	1	1	1
16	Pire, S.M. 18	Argentina	2	1	3.5	1.8	1	1	1
17	Krapovickas, A. *et al.* 26453	Argentina	2	1	5.7	2	1	1	1
18	Ferrucci, M.S. 198	Argentina	2	1	4.8	1.7	1	1	1
19	Schinini, A & Cristóbal, C.L. 13637	Argentina	2	1	5.1	1.9	1	1	1
20	Vanni, R.O. *et al.* 79	Argentina	2	3	4.9	2.5	1	1	1
21	Solís Neffa, V. 12	Argentina	2	1	8.2	3.4	1	1	1
22	Solís Neffa, V. 2	Argentina	2	1	5.9	2.4	1	1	1
23	Pedersen, T. M. 3954	Argentina	2	2	4.9	2.6	1	1	1
24	Schinini, A. 4861	Argentina	2	1	4.3	1.9	1	1	1
25	Krapovickas, A. *et al.* 19596	Argentina	2	1	5.3	2.4	1	1	1
26	Ferrucci, M.S. *et al.* 61	Argentina	2	1	4	1.3	1	1	1
27	Ferrucci, M.S. *et al.* 33	Argentina	2	2	3.1	2	1	1	1
28	Ferrucci, M.S. *et al.* 42	Argentina	2	1	5.2	2.3	1	1	1
29	Coulleri, J.P. *et al.* 96	Argentina	2	2	12	7	1	1	1
30	Ferrucci, M.S. & Solís Neffa V. 895	Argentina	2	2	3.6	2.4	1	1	1
31	Schulz, A.G. 7336	Argentina	2	1	6.3	3.2	1	1	1
32	Schulz, A.G. 2258	Argentina	2	1	5.2	2.3	1	1	1
33	Schulz, A.G. 17091	Argentina	2				1	1	1
34	Schulz, A.G. 1891	Argentina	2	1	4.3	2.1	1	1	1
35	Schulz, A.G. 1898	Argentina	2	1	3.5	1.4	1	1	1
36	Schulz, A.G. 1897	Argentina	2	1	7.4	3.6	1	1	1
37	Schulz, A.G. 13992	Argentina	2	1	4.6	2	1	1	1
38	Schulz, A.G. 10466	Argentina	2	1	3.1	1.6	1	1	1
39	Schulz, A.G. 14581	Argentina	2	1	2.7	1	1	1	1
40	Schulz, A.G. 15198	Argentina	2				1	1	1
41	Schulz, A.G. 15753	Argentina	2	2	9.7	6.7	1	1	1
42	Schulz, A.G. 17874	Argentina	2	1	7.5	2	1	1	1
43	Schulz, A.G. 14581	Argentina	2				1	1	1
44	Schulz, A.G. 17900	Argentina	2	1	2.3	0.9	1	1	1
45	Schulz, A.G. 1912	Argentina	2	1	4.1	1.5	1	1	1
46	Bordón, A.O. 408536	Argentina	2	1	5.9	3	1	1	1
47	Bordón, A.O. 408524	Argentina	2	1	5.1	2.2	1	1	1
48	Salgado C.R. 480	Argentina	2	2	3.1	2.3	1	1	1
49	Fortunato, R. 6578	Argentina	2	3	3.3	2.8	1	3	1
50	Valla, J.J. *et al.* 120	Argentina	2	2	4.5	3.3	1	3	1
51	Insfrán, P. 889	Argentina	2	1	6.3	3.2	1	1	1
52	Saravia-Toledo, C. 11997	Argentina	2				1	1	1

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TABLE 1. (Continued)

Sample ID	Collector and Number	Country	LBD	STL	LTL	WTL	ATL	MTL	Indument
53	Saravia-Toledo, C. 13931	Argentina	2	1	6.3	3.5	2	1	1
54	Saravia-Toledo, C. 14389	Argentina	2	1	8.5	5.4	2	1	1
55	Grüner, C. 381	Argentina	2				1	1	1
56	Arbo, M.M. *et al.* 2341	Argentina	2	1	6.5	3.1	1	1	1
57	Grondona, E. & Spagazzini M.1113	Argentina	2	1	4.4	2	1	1	1
58	Keller, H. & Franco, M. 5769	Argentina	2	1	3.7	1.6	1	1	1
59	Keller, H.A. 8824	Argentina	2	1	4.3	2.2	1	1	1
60	Keller, H.A.	Argentina	2	1	4.5	1.9	1	1	1
61	Montes, J. 15427	Argentina	2	1	6.6	3.3	1	1	1
62	Montes, J. 9392	Argentina	2	1	9.2	4.8	1	1	1
63	Guaglianone, E.R. *et al.* 2729	Argentina	2	1	6.5	3.4	2	1	1
64	Guaglianone, E.R. *et al*. 2616	Argentina	2	2	7.9	5	1	1	1
65	Guaglianono, E.R. *et al.* 2564	Argentina	2	1	8	3.8	1	1	1
66	Dematteis, M. & Seijo, G. 818	Argentina	1	1	3.5	1.5	1	2	2
67	Saravia-Toledo, C. 11987	Argentina	1	2	4	2.7	1	2	2
68	Fortunato, R. *et al. 2378*	Argentina	2	2	2.3	1.6	1	3	1
69	Novara, L. *et al.* 10413	Argentina	2	2	4.5	2.8	1	1	1
70	Di Giacomo, A.	Argentina	2	1	4.6	2.3	1	1	1
71	Meza Torres, E. I. *et al.* 1329	Argentina	2	2	6.2	3.5	2	1	1
72	Schwindt, E. 4883	Argentina	2	1	4.7	2.4	1	1	1
73	Cabrera, A. L. & Troncoso, N.S. 29292	Argentina	2	2	5.4	2.9	1	1	1
74	Cabrera, A.L. & Troncoso, N.S. 29259	Argentina	2	1	5	1.9	1	1	1
75	Schinini, A. 25464	Argentina	2	1	4.7	1.8	1	1	1
76	Coulleri, J.P. *et al.* 25	Bolivia	1	2	15	10.4	1	2	2
77	Coulleri, J.P. *et al.* 48	Bolivia	1	2	4	2.2	1	2	2
78	Coulleri, J.P. *et al.* 59	Bolivia	2	2	8	5	1	1	1
79	Coulleri, J.P. *et al.* 62	Bolivia	2	3	7.3	5.9	1	1	1
80	Dematteis, M. *et al.* 3581	Bolivia	1				1	2	2
81	Ferrucci, M.S. *et al.* 1895	Bolivia	1	2	13	8.2	1	2	2
82	Ferrucci, M.S. *et al.* 2321	Bolivia	1	2	13.3	8	1	2	2
83	Ferrucci, M.S. 1834	Bolivia	1				1	2	2
84	Ferrucci, M.S. 1747	Bolivia	2	1	5.3	2.8	1	1	2
85	Mostacedo, B. & Dahlberg, S.V. 2381	Bolivia	1	2	4	2.8	1	2	2
86	Ferrucci, M.S. *et al.* 1729	Bolivia	2	1	6.8	3.2	1	1	2
87	Coulleri, J.P. *et al.* 11	Bolivia	1	1	9.5	3.4	2	2	2
88	Coulleri, J.P. *et al. 4*	Bolivia	1	3	7.8	6	1	2	2
89	Lozano, R. *et al.* 1506	Bolivia	2	1	8.6	4.6	1	1	1
90	Beck, St. G. 31503	Bolivia	1	2	11	6.3	1	2	2
91	Beck, St. G. 31391	Bolivia	2	1	7.3	3.2	1	1	1
92	Lliully, A. *et al.* 352	Bolivia	2	1	7.4	3.5	1	1	1
93	Plata, O. *et al.* 32	Bolivia	2	1	4.4	2.4	1	1	1
94	Foster, P.F. 313	Bolivia	1	3	4.4	3.5	1	2	2
95	Rodríguez, P. *et al.* 2	Bolivia	1	2	3.2	2	1	2	2
96	Lozano, R. *et al.* 1348	Bolivia	2	1	5.5	3	1	1	1
97	Roca, A. & Romero, J. 0532	Bolivia	1	2	3.9	2.5	1	2	2
98	Bourdy, G. 2032	Bolivia	1	3	3	2.4	1	3	2
99	Shirley, O.S. 168	Bolivia	1	4	8	5	1	2	2
100	Beck, St. G. & Liberman, M. 9420	Bolivia	2	4	1.8	1.4	1	3	1
101	Beck, St. G. *et al.* 11614	Bolivia	2	1	4.5	2	1	1	1
102	Mostacedo, B. 2303	Bolivia	2	2	2.9	1.8	1	1	1
103	Villegas, M. & Manchego, G. 221	Bolivia	2	1	4.4	1.8	1	3	1
104	Hatschbach, G. *et al.* 76341	Brazil	1	4	8.8	8	1	2	2
105	Souza, V.C. *et al.* 26799	Brazil	2	1	4.2	2.1	1	1	1
106	Hatschbach, G. *et al.* 76050	Brazil	2	1	4	1.5	1	1	1
107	Hatschbach, G. *et al.* 66763	Brazil	1	2	20.7	13.5	1	2	2
108	Siquino, A.S. 43577	Brazil	1				1	2	2
109	Araujo, G.M. & Silva, R. 43513	Brazil	1	3	3.9	3	1	2	2

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TABLE 1. (Continued)

Sample ID	Collector and Number	Country	LBD	STL	LTL	WTL	ATL	MTL	Indument
110	Cervi, A.C. *et al.* 3368	Brazil	2	2	7.2	4	1	1	1
111	Dubs, B. & Kramer, 1097	Brazil	1	2	8.5	4.8	1	2	2
112	Dubs, B. & Kramer, 1120	Brazil	1	2	11.1	7	1	2	2
113	Acevedo-Rodríguez, P. *et al.* 1509	Brazil	1	2	8.5	5.4	1	2	2
114	Acevedo-Rodríguez, P. *et al.* 1482	Brazil	1	1	10	4.9	1	2	2
115	Hatschbach, G. *et al.* 63833	Brazil	1	2	9.3	6.1	1	2	2
116	Zardini, E. & Velazquez, C. 6329	Paraguay	2	1	4	1.8	1	1	1
117	Vanni, R. *et al.* 1937	Paraguay	2	1	3.7	1.8	1	3	1
118	Arenas, P. 891	Paraguay	2	1	8.5	4.3	1	1	1
119	Schinini, A. *et al.* 21081	Paraguay	2	2	3.1	2.1	1	3	1
120	Soria, N. 1244	Paraguay	2	3	3.8	3.9	1	3	1
121	Schinini, A. & Bordas, E. 13348	Paraguay	2	1	2.4	0.4	1	1	1
122	Zardini, E. & Florentín, T. 6951	Paraguay	2	1	5.5	2	1	1	1
123	Landrum, S. *et al.* 8570	Paraguay	2	1	8	3.4	1	1	2
124	Arenas, P. 1523	Paraguay	2	2	2.9	2.2	1	3	1
125	Soria, N. 4784	Paraguay	2	1	4.4	1.8	1	1	1
126	Zardini, E. 7192	Paraguay	2	1	5	2	1	1	1
127	Zardini, E. & Degen, R.3503	Paraguay	2	1	7	3.4	1	1	1
128	Schinini, A. & Bordas, E. 20637	Paraguay	2	1	4	1.4	1	1	1
129	Pérez, L. *et al.* 2741	Paraguay	2	1	4.7	2.3	1	3	1
130	Landrum, S. *et al.* 8647	Paraguay	2	1	8.1	4	1	1	1
131	August, L. 363	Paraguay	2	2	3.3	2.2	1	3	1
132	Friesen, J. 27	Paraguay	2	2	2.4	1.8	1	3	1
133	Pérez, L. *et al.* 93	Paraguay	2	1	6.4	3.3	1	1	1
134	Basualdo, I. 1050	Paraguay	2	1	2.7	1.4	1	1	1
135	Schinini, A. 5030	Paraguay	2	1	6.7	3.1	1	1	1
136	Arbo, M.M. *et al.* 1678	Paraguay	2	1	6.4	3	1	1	1
137	Ferrucci, M.S. *et al.* 744	Paraguay	2	1	5.5	2.9	1	1	1
138	Soria, N. 201	Paraguay	2	1	6.3	3.5	1	1	1
139	Pérez, L. 264	Paraguay	2	1	4.4	2.4	1	1	1
140	Aregras, P. 3306	Paraguay	2	3	2.4	3.3	1	3	1
141	Schinini, A. 15367	Paraguay	2	1	3.3	1	1	1	1
142	Woolston, A. 1009	Paraguay	2	1	3.8	1.8	1	1	2
143	Ferrucci, M.S. 167	Paraguay	2	1	3.5	1.7	1	1	2
144	Schinini, A. 15379	Paraguay	2	1	4.75	1.75	1	1	1

TABLE 2. Bioclimatic variables for each specimen of *S. perulacea*. Sample ID: Collectors number. Bio1: Annual mean temperature. Bio 2: Mean monthly temperature range. Bio 3: Isothermality. Bio 4: Temperature seasonality. Bio 5: Maximum temperature of warmest month. Bio 6: Minimum temperature of coldest month. Bio 7: Temperature annual range. Bio 8: Mean temperature of wettest quarter. Bio 9: Mean temperature of driest quarter. Bio 10: Mean temperature of warmest quarter. Bio 11: Mean temperature of coldest quarter. Bio 12: Annual precipitation. Bio 13: Precipitation of wettest month. Bio 14: Precipitation of driest month. Bio 15: Precipitation seasonality. Bio 16: Precipitation of wettest quarter. Bio 17: Precipitation of driest quarter. Bio 18: Precipitation of warmest quarter. Bio 19: Precipitation of coldest quarter.

Sample ID	Bio 1	Bio 2	Bio 3	Bio 4	Bio 5	Bio 6	Bio 7	Bio 8	Bio 9	Bio 10	Bio 11	Bio 12	Bio 13	Bio 14	Bio 15	Bio 16	Bio 17	Bio 18	Bio 19
1	22.6	11.0	49.0	420.8	34.3	11.8	22.5	22.7	17.6	27.7	17.6	1663	197	69	28.6	523	269	430	269
2	22.0	10.9	48.9	423.2	33.6	11.3	22.3	24.8	16.8	27.1	16.8	1295	172	45	38.8	444	160	394	160
3	22.0	11.1	49.8	430.7	33.7	11.4	22.3	25.0	16.7	27.2	16.7	1276	162	43	41.5	441	141	414	141
4	20.7	12.0	50.4	421.4	33.1	9.2	23.9	20.6	15.6	26.0	15.6	1546	167	88	18.3	469	308	357	308
5	21.1	11.4	49.0	427.8	33.1	9.8	23.3	23.8	15.8	26.4	15.8	1122	138	42	37.0	385	140	344	140
6	20.8	12.1	50.8	418.5	33.1	9.3	23.8	20.7	15.7	26.0	15.7	1549	168	88	18.4	471	309	357	309
7	22.4	11.1	49.9	414.9	34.0	11.7	22.3	22.5	17.4	27.4	17.4	1693	188	78	23.2	503	302	429	302
8	22.4	11.2	50.1	415.8	34.1	11.7	22.4	22.4	17.3	27.4	17.3	1648	177	77	22.4	484	291	419	291
9	21.9	11.1	50.1	428.5	33.6	11.4	22.2	25.0	16.6	27.1	16.6	1245	162	42	41.3	435	140	398	140
10	21.7	11.1	49.6	428.3	33.4	11.0	22.4	24.6	16.4	26.9	16.4	1265	160	44	40.3	436	145	406	145
11	22.0	11.1	49.8	430.4	33.7	11.4	22.3	25.1	16.7	27.2	16.7	1259	162	42	41.6	438	140	406	140
12	22.2	11.3	50.8	410.1	33.8	11.6	22.2	22.3	17.2	27.1	17.2	1649	172	80	20.7	472	300	421	300

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TABLE 2. (Continued)

Sample ID	Bio 1	Bio 2	Bio 3	Bio 4	Bio 5	Bio 6	Bio 7	Bio 8	Bio 9	Bio 10	Bio 11	Bio 12	Bio 13	Bio 14	Bio 15	Bio 16	Bio 17	Bio 18	Bio 19
13	21.7	11.1	49.6	430.0	33.5	11.1	22.4	24.7	16.4	27.0	16.4	1264	160	44	40.3	435	145	406	145
14	22.0	11.1	49.8	430.6	33.7	11.4	22.3	25.0	16.7	27.2	16.7	1274	161	42	41.6	440	140	414	140
15	21.8	11.1	49.4	429.3	33.5	11.0	22.5	24.7	16.5	27.0	16.5	1288	161	43	41.5	443	141	420	141
16	21.6	11.1	49.0	426.6	33.4	10.7	22.7	24.4	16.3	26.8	16.3	1235	156	44	39.5	426	145	391	145
17	21.7	11.1	49.6	428.3	33.4	11.0	22.4	24.6	16.4	26.9	16.4	1265	160	44	40.3	436	145	406	145
18	22.0	11.1	49.8	430.6	33.7	11.4	22.3	25.0	16.7	27.2	16.7	1274	161	42	41.6	440	140	414	140
19	22.0	11.1	49.8	429.8	33.7	11.4	22.3	25.0	16.7	27.2	16.7	1255	163	42	41.5	437	140	402	140
20	22.0	10.9	49.0	423.5	33.6	11.4	22.2	24.8	16.7	27.1	16.7	1287	171	45	38.5	441	160	389	160
21	22.0	11.1	49.8	430.4	33.7	11.4	22.3	25.1	16.7	27.2	16.7	1259	162	42	41.6	438	140	406	140
22	22.0	11.1	49.8	430.7	33.7	11.4	22.3	25.0	16.7	27.2	16.7	1276	162	43	41.5	441	141	414	141
23	21.9	11.1	49.8	428.0	33.6	11.4	22.2	24.9	16.7	27.1	16.7	1249	163	42	40.9	435	142	396	142
24	21.9	10.9	49.5	423.9	33.5	11.4	22.1	24.8	16.7	27.0	16.7	1281	170	45	38.7	440	158	390	158
25	21.9	10.9	49.4	424.5	33.5	11.4	22.1	24.8	16.7	27.1	16.7	1282	170	45	38.6	440	158	390	158
26	21.9	10.9	49.4	423.5	33.5	11.4	22.1	24.8	16.7	27.1	16.7	1286	171	45	38.4	441	160	390	160
27	21.9	10.9	49.5	423.9	33.5	11.4	22.1	24.8	16.7	27.0	16.7	1281	170	45	38.7	440	158	390	158
28	22.0	11.0	49.4	424.4	33.6	11.4	22.2	24.9	16.7	27.1	16.7	1277	169	44	39.5	440	153	394	153
29	21.9	11.0	49.6	426.0	33.5	11.4	22.1	24.9	16.7	27.1	16.7	1273	168	44	39.2	439	154	392	154
30	21.5	11.2	49.5	425.2	33.1	10.4	22.7	24.3	16.3	26.7	16.3	1313	163	41	43.6	454	137	435	137
31	21.8	11.2	49.8	426.3	33.5	11.0	22.5	24.7	16.6	27.0	16.6	1298	168	41	41.9	449	143	413	143
32	21.4	11.4	49.9	422.7	33.1	10.2	22.9	24.1	16.2	26.6	16.2	1304	162	40	44.1	453	134	432	134
33	21.4	11.4	49.9	422.7	33.1	10.2	22.9	24.1	16.2	26.6	16.2	1304	162	40	44.1	453	134	432	134
34	21.7	11.2	49.4	425.7	33.3	10.7	22.6	24.5	16.5	26.9	16.5	1308	164	41	43.0	451	138	430	138
35	21.7	11.7	50.5	422.0	33.5	10.3	23.2	24.4	16.5	26.8	16.5	1279	164	38	43.2	443	135	408	135
36	21.5	11.2	49.4	424.3	33.1	10.4	22.7	24.3	16.3	26.7	16.3	1317	163	41	43.5	455	137	437	137
37	21.5	11.2	49.4	424.3	33.1	10.4	22.7	24.3	16.3	26.7	16.3	1317	163	41	43.5	455	137	437	137
38	21.5	11.2	49.4	424.3	33.1	10.4	22.7	24.3	16.3	26.7	16.3	1317	163	41	43.5	455	137	437	137
39	21.7	11.2	49.4	425.0	33.3	10.7	22.6	24.5	16.5	26.9	16.5	1308	164	41	43.0	451	138	430	138
40	21.5	11.2	49.4	423.6	33.1	10.4	22.7	24.3	16.3	26.7	16.3	1316	163	41	43.5	454	137	436	137
41	21.6	11.1	49.3	422.7	33.1	10.6	22.5	24.3	16.4	26.8	16.4	1314	162	41	43.2	452	137	436	137
42	21.6	11.1	49.3	422.7	33.1	10.6	22.5	24.3	16.4	26.8	16.4	1314	162	41	43.2	452	137	436	137
43	21.7	11.2	49.4	425.7	33.3	10.7	22.6	24.5	16.5	26.9	16.5	1308	164	41	43.0	451	138	430	138
44	21.4	11.3	49.5	422.9	33.1	10.2	22.9	24.1	16.2	26.6	16.2	1312	162	41	43.8	455	136	436	136
45	21.3	11.1	49.3	419.3	32.9	10.3	22.6	26.1	16.2	26.5	16.2	1324	162	42	43.6	457	138	443	138
46	21.5	14.1	53.4	435.0	34.7	8.3	26.4	26.1	16.1	26.8	16.1	1009	134	20	55.7	388	72	382	72
47	21.4	13.7	53.2	430.0	34.3	8.5	25.8	26.0	16.1	26.7	16.2	1001	129	23	52.9	375	77	361	77
48	21.8	13.4	53.4	419.6	34.3	9.2	25.1	26.4	16.7	26.9	16.7	1048	138	23	48.3	376	94	344	94
49	22.8	13.9	54.6	417.2	34.9	9.4	25.5	26.5	17.6	27.6	17.4	684	117	8	71.9	321	35	314	51
50	23.1	13.0	54.7	386.7	34.9	11.2	23.7	27.2	19.5	27.8	18.3	1030	122	17	40.6	344	115	316	117
51	21.6	13.2	52.9	418.9	34.1	9.2	24.9	24.1	16.5	26.7	16.5	1120	142	26	46.4	391	106	358	106
52	20.6	12.9	52.4	411.3	31.6	7.0	24.6	25.1	16.9	25.1	15.1	1000	195	4	90.6	551	24	551	25
53	21.3	12.6	51.0	419.7	32.3	7.5	24.8	25.1	15.7	25.9	15.7	733	143	4	93.3	416	18	392	18
54	22.5	12.2	50.2	421.6	33.4	9.2	24.2	27.0	16.8	27.0	16.8	968	196	4	90.9	535	21	535	21
55	21.1	12.7	55.0	382.5	33.0	9.9	23.1	21.2	17.4	25.7	16.5	1736	214	103	19.5	507	353	434	360
56	21.2	12.1	53.5	390.1	32.9	10.3	22.6	23.4	16.5	26.0	16.5	1641	173	91	17.6	460	319	438	319
57	21.0	12.2	53.1	385.7	32.9	9.9	23.0	20.7	17.4	25.7	16.4	1679	180	99	16.1	483	344	399	363
58	20.8	12.4	54.2	380.0	32.6	9.7	22.9	17.6	17.4	25.3	16.2	1734	183	106	15.8	498	363	407	389
59	21.1	12.1	53.7	386.4	32.7	10.1	22.6	23.4	16.5	25.9	16.5	1617	171	91	17.3	455	314	434	314
60	21.0	12.4	54.1	380.1	32.9	10.0	22.9	17.7	17.8	25.4	16.4	1744	186	113	14.1	487	377	412	437
61	20.2	13.5	56.1	387.2	31.9	7.9	24.0	20.0	16.3	24.8	15.4	1591	169	77	22.4	478	279	420	289
62	21.0	13.9	57.0	393.9	32.9	8.6	24.3	24.9	17.2	25.7	16.2	1625	172	85	22.3	463	291	439	297
63	22.0	12.5	50.7	425.2	33.1	8.5	24.6	26.6	18.2	26.6	16.3	1136	214	4	88.0	619	29	619	32
64	21.3	12.6	51.5	415.5	32.2	7.7	24.5	25.0	15.8	25.8	15.8	772	151	4	92.2	431	20	408	20
65	20.7	12.7	51.8	411.9	31.6	7.1	24.5	24.4	15.3	25.2	15.3	792	154	4	92.8	445	20	424	20
66	20.7	12.7	51.8	411.9	31.6	7.1	24.5	24.4	15.3	25.2	15.3	792	154	4	92.8	445	20	424	20
67	20.6	12.7	51.9	411.9	31.5	7.0	24.5	24.3	15.2	25.1	15.2	785	154	4	93.2	444	20	423	20
68	22,4	13.5	54.6	411.8	34.3	9.6	24.7	26.8	17.5	27.4	17.3	909	133	18	57.3	360	62	345	95
69	21.7	13.6	53.2	415.1	34.5	9.0	25.5	24.3	16.6	26.8	16.7	1189	150	29	41.8	400	131	338	131
70	22.3	12.2	50.1	421.7	33.3	9.0	24.3	26.8	16.6	26.8	16.6	975	197	4	90.9	537	21	537	21
71	21.8	12.7	51.5	420.6	32.9	8.2	24.7	26.4	18.1	26.4	16.1	1191	222	4	87.2	645	31	645	35

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TABLE 2. (Continued)

Sample ID	Bio 1	Bio 2	Bio 3	Bio 4	Bio 5	Bio 6	Bio 7	Bio 8	Bio 9	Bio 10	Bio 11	Bio 12	Bio 13	Bio 14	Bio 15	Bio 16	Bio 17	Bio 18	Bio 19
72	20.8	12.3	53.9	381.6	32.5	9.7	22.8	17.9	17.1	25.5	16.2	1692	188	97	16.6	460	343	422	355
73	20.9	12.5	54.8	381.1	32.6	9.8	22.8	20.9	17.2	25.6	16.3	1742	204	104	17.5	496	355	443	359
74	21.0	12.2	53.8	382.3	32.7	10.0	22.7	23.2	17.3	25.7	16.4	1670	185	95	16.7	457	336	421	345
75	21.0	12.5	54.5	379.5	32.7	9.8	22.9	21.1	17.3	25.6	16.4	1725	206	100	18.4	492	349	440	355
76	23.5	14.4	67.6	188.9	33.1	11.8	21.3	24.9	20.9	25.1	20.8	1234	208	20	66.4	585	79	278	110
77	25.0	13.0	67.8	222.6	34.0	14.8	19.2	27.1	23.4	27.1	22.0	1096	163	20	52.3	445	104	434	138
78	21.3	11.8	68.2	200.8	29.1	11.8	17.3	23.2	19.6	23.2	18.5	932	140	16	52.8	395	98	395	126
79	16.9	12.3	72.3	175.8	24.5	7.5	17.0	18.7	14.7	18.7	14.4	684	129	11	78.7	364	40	364	47
80	24.2	13.2	66.8	200.6	33.0	13.2	19.8	25.8	21.4	25.8	21.4	1332	228	27	62.9	628	111	424	149
81	23.8	13.9	69.3	171.8	32.8	12.7	20.1	25.1	21.4	25.2	21.3	1177	196	18	66.7	546	70	276	102
82	24.5	12.1	69.5	192.8	32.4	15.0	17.4	26.2	23.2	26.2	21.8	1064	189	25	60.4	486	106	449	131
83	24.1	10.8	63.3	235.1	32.0	14.9	17.1	26.4	21.1	26.4	20.8	1278	211	45	50.2	540	168	540	181
84	14.8	16.8	63.8	330.3	25.9	-0.4	26.3	18.1	12.1	18.1	10.3	584	119	1	97.9	346	12	346	13
85	23.3	13.2	70.2	184.0	31.7	12.9	18.8	24.7	20.8	24.9	20.6	1136	182	21	60.6	506	88	478	116
86	22.7	12.4	50.7	430.6	33.7	9.2	24.5	27.3	18.8	27.3	16.8	1216	226	4	86.3	656	33	656	37
87	23.7	12.3	69.7	181.0	31.8	14.2	17.6	25.1	21.2	25.3	21.1	1096	190	25	60.6	499	105	339	127
88	24.5	11.7	69.3	196.9	32.2	15.3	16.9	26.3	23.1	26.3	21.7	983	175	28	55.7	437	111	409	137
89	18.0	15.3	61.2	319.5	28.6	3.6	25.0	21.4	15.4	21.4	13.6	674	132	2	94.7	387	14	387	16
90	20.1	14.2	56.5	362.3	30.9	5.7	25.2	24.1	17.0	24.1	15.2	906	175	3	89.3	488	15	488	29
91	21.0	13.3	54.3	389.6	31.8	7.3	24.5	25.2	17.6	25.2	15.7	1091	199	5	86.1	573	25	573	33
92	19.1	12.7	62.4	270.2	28.2	7.9	20.3	21.8	15.5	21.8	15.4	921	185	8	91.9	532	33	418	43
93	19.1	12.7	62.4	270.2	28.2	7.9	20.3	21.8	15.5	21.8	15.4	921	185	8	91.9	532	33	418	43
94	24.4	13.4	70.3	137.5	32.9	13.8	19.1	25.3	22.5	25.5	22.3	1368	240	15	71.1	648	65	313	99
95	20.6	13.6	54.7	383.3	31.5	6.7	24.8	24.8	17.3	24.8	15.4	1060	193	5	87.0	562	23	562	32
96	22.3	13.4	55.8	349.0	32.7	8.6	24.1	25.3	19.3	26.1	17.6	846	159	3	89.1	458	18	455	26
97	24.8	13.1	62.7	285.8	34.5	13.6	20.9	27.6	22.6	27.6	21.0	501	78	5	63.0	219	28	219	53
98	24.5	13.2	62.7	276.3	34.1	13.1	21.0	27.2	22.3	27.2	20.9	561	93	3	69.9	260	28	260	50
99	23.2	13.4	69.8	185.9	31.8	12.6	19.2	24.7	20.7	24.9	20.5	1122	180	24	60.8	499	87	477	118
100	23.7	13.2	58.3	334.9	33.9	11.3	22.6	27.1	21.2	27.1	19.2	600	109	4	83.1	311	17	311	37
101	20.5	13.5	54.8	370.5	31.3	6.6	24.7	24.0	17.4	24.6	15.6	968	184	3	85.2	503	14	484	44
102	24.1	12.7	69.1	184.2	32.4	14.1	18.3	25.6	21.7	25.8	21.5	1099	185	20	63.5	504	89	355	116
103	25	13.1	62.9	273.1	34.7	13.9	20.8	27.6	21.5	27.7	21.5	534	87	5	66.4	239	30	238	49
104	25.2	11.4	64.5	241.1	33.2	15.5	17.7	27.5	21.9	27.5	21.9	1296	220	26	58.7	571	109	571	109
105	24.7	11.4	58.6	295.9	33.8	14.4	19.4	27.7	20.8	28.0	20.8	1319	169	48	40.4	488	153	460	209
106	23.4	11.4	69.0	179.0	30.8	14.3	16.5	24.9	21.3	25.0	20.9	1430	229	32	53.9	594	115	575	182
107	22.6	12.2	69.9	134.5	30.2	12.8	17.4	23.7	20.8	23.7	20.6	1577	231	11	67.6	682	55	679	95
108	21.3	12.2	67.5	172.8	29.1	11.0	18.1	22.6	19.8	22.9	19.0	1332	297	7	93.6	764	27	568	87
109	21.2	12.2	67.4	173.5	29.0	10.9	18.1	22.5	19.7	22.8	18.9	1331	302	6	93.9	759	24	569	87
110	24.9	11.6	63.2	251.2	33.2	14.9	18.3	27.4	21.5	27.4	21.5	1316	213	28	54.5	557	119	557	119
111	22.8	12.0	67.6	220.3	30.7	12.9	17.8	24.8	19.9	24.8	19.7	1454	236	31	53.9	612	124	612	189
112	26.0	12.1	66.3	177.0	34.2	16.0	18.2	27.4	23.8	27.4	23.4	1347	226	16	70.8	647	57	325	99
113	21.4	12.0	66.5	185.3	29.4	11.3	18.1	22.9	19.3	23.3	18.9	1390	315	7	92.0	784	26	566	43
114	20.5	12.1	64.3	203.0	29.1	10.3	18.8	22.2	17.9	22.6	17.7	1472	337	8	90.5	824	29	584	50
115	26.3	12.6	65.5	193.3	34.9	15.7	19.2	27.4	24.5	27.9	23.5	1293	239	15	74.1	636	57	293	92
116	23.1	11.9	54.8	373.2	34.1	12.4	21.7	25.2	18.4	27.5	18.4	1420	162	46	35.8	469	178	456	178
117	24.8	12.9	57.4	356.1	35.5	13.0	22.5	28.7	20.3	28.7	20.1	660	93	6	55.7	258	47	258	79
118	23.2	10.7	52.8	365.5	33.4	13.1	20.3	27.0	18.7	27.5	18.7	1373	162	51	35.6	442	173	441	173
119	25.1	12.9	57.2	354.6	35.8	13.3	22.5	29.0	22.2	29.0	20.3	700	98	8	56.8	276	49	276	79
120	24.8	13.0	56.8	365.5	35.7	12.8	22.9	28.9	20.2	28.9	20.0	687	99	6	56.8	277	48	277	81
121	23.2	11.9	54.4	369.6	34.3	12.5	21.8	25.3	18.6	27.7	18.6	1344	157	46	36.2	446	169	439	169
122	22.9	11.7	54.1	374.4	33.9	12.3	21.6	26.8	18.3	27.4	18.3	1394	155	48	34.4	452	182	445	182
123	22.0	11.2	53.2	371.8	32.6	11.6	21.0	25.8	18.4	26.5	17.4	1488	176	59	28.7	466	229	414	238
124	24.9	13.0	56.7	363.5	35.8	12.9	22.9	28.9	20.3	28.9	20.1	688	99	6	56.6	276	48	276	81
125	22.5	11.8	61.8	263.1	31.3	12.2	19.1	25.0	19.1	25.2	19.0	1384	169	42	36.0	480	171	448	239
126	21.7	10.8	53.8	346.4	31.7	11.7	20.0	25.8	17.4	25.8	17.4	1443	166	47	37.2	480	176	480	176
127	22.4	10.8	53.6	354.1	32.5	12.4	20.1	26.6	18.1	26.6	18.1	1392	159	49	35.6	454	173	454	173
128	23.9	11.6	60.3	274.5	32.7	13.5	19.2	26.5	20.2	26.7	20.2	1379	180	48	36.1	494	185	413	185
129	23.3	13.3	56.2	382.5	34.7	11.0	23.7	27.0	18.5	27.8	18.4	658	90	10	54.9	260	48	260	81
130	24.9	13.0	56.7	363.2	35.9	13.0	22.9	29.0	22.0	29.0	20.2	715	104	7	57.2	291	50	291	83

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TABLE 2. (Continued)

Sample ID	Bio 1	Bio 2	Bio 3	Bio 4	Bio 5	Bio 6	Bio 7	Bio 8	Bio 9	Bio 10	Bio 11	Bio 12	Bio 13	Bio 14	Bio 15	Bio 16	Bio 17	Bio 18	Bio 19
131	24.9	13.0	56.7	363.2	35.9	13.0	22.9	29.0	22.0	29.0	20.2	715	104	7	57.2	291	50	291	83
132	22.2	11.0	52.3	370.9	32.7	11.7	21.0	25.9	18.6	26.7	17.6	1515	186	60	30.5	491	232	430	243
133	23.3	11.6	54.3	371.9	34.3	12.9	21.4	25.5	18.7	27.8	18.7	1388	164	48	34.9	447	178	444	178
134	22.3	10.8	52.1	367.5	32.4	11.7	20.7	26.0	18.7	26.6	17.7	1484	183	64	32.2	488	225	437	234
135	22.8	11.0	53.7	364.9	33.0	12.6	20.4	26.6	18.2	27.1	18.2	1377	158	50	34.7	444	176	440	176
136	23.4	11.7	54.4	372.2	34.4	12.9	21.5	25.6	18.8	27.9	18.8	1401	163	47	35.0	453	179	448	179
137	21.8	10.7	53.4	343.8	31.9	11.8	20.1	25.9	17.7	25.9	17.7	1434	166	45	37.7	481	171	481	171
138	21.7	10.7	53.8	345.2	31.6	11.8	19.8	25.4	17.5	25.8	17.5	1453	167	49	35.3	470	186	470	186
139	23.3	11.2	53.3	368.2	33.9	12.9	21.0	27.7	18.7	27.7	18.7	1316	169	48	38.3	429	166	429	166
140	25	12.9	57.2	355.6	35.8	13.2	22.6	28.9	20.5	28.9	20.3	714	101	7	56.0	283	52	283	84
141	22.5	11.5	53.1	379.4	33.7	12.1	21.6	26.7	17.8	27.1	17.8	1427	171	57	33.5	471	189	467	189
142	22.4	10.3	53.8	347.9	31.8	12.7	19.1	24.7	18.1	26.4	18.1	1349	164	52	33.4	455	186	419	186
143	21.8	11.3	50.8	394.5	32.9	10.7	22.2	24.3	17.0	26.6	17.0	1527	177	62	28.9	465	226	436	226
144	23.1	10.8	53.2	366.8	33.3	13.1	20.2	26.9	18.6	27.4	18.6	1375	160	52	34.9	446	176	440	176

Results

Morphological analysis:—The PCoA recognized three groups within the specimens of *S. perulacea* (Fig. 1). The first two principal axes accounted for 65.3% of the overall variation across the specimens; 43.7% and 21.6%, respectively. The specimens belonging to one group, from here on the morphotype A, were ochraceous-pubescent plants, with leaves imparipinnate, 2-jugate, the lower jugae 3-foliolate, large terminal leaflet, widely ovate, obovate or widely obovate with obtuse or retuse apex and dentate-serrate margin, with inconspicuous obtuse teeth. The second group, morphotype B, consisted of glabrous plants with leaves imparipinnate 3-jugate, the lower jugae 5-foliolate, with a medium terminal leaflet, narrow ovate or ovate, with acute apex, dentate-serrate margin, and with acute teeth. The specimens of the third group, morphotype C, had intermediate features between morphotypes A and B, characterized by scarce indument or glabrous plants, leaves imparipinnate 2–3-jugate, the lower 3 or 5-foliolate, with small terminal leaflets, ovate or wide ovate, a retuse apex and inciso-dentate margin.

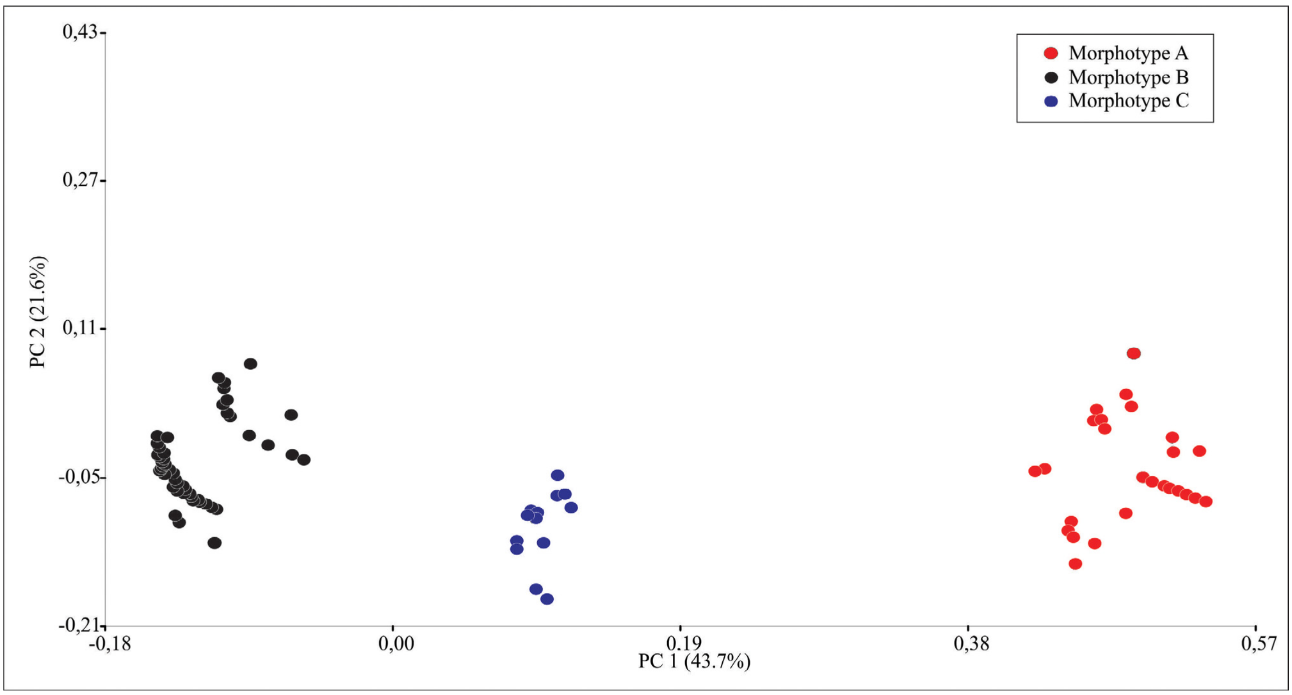

FIGURE 1. Principal coordination analyses (PCoA) of the seven morphological characters measured from 144 specimens of *Serjania perulacea*. Red circles: morphotype A (*S. perulacea* var. *perulacea*). Black circles: morphotype B (*S. perulacea* var. *krapovickasii*). Blue circles: morphotype C (*S. perulacea* var. *chacoensis*).

The PCA to the same data set used in the PCoA revealed that the first two components accounted 71.58% of the total variation. The first component explained the 54.4% of the variability, traits such as leaf blade dissection, width of the terminal leaflet and indumenta were the most influential variables (Fig. 2, Table 3). Characters with the highest weight along the second component were related to the size of the terminal leaflet, i.e. length and width. The contribution of each variable to the component is shown in Table 3.

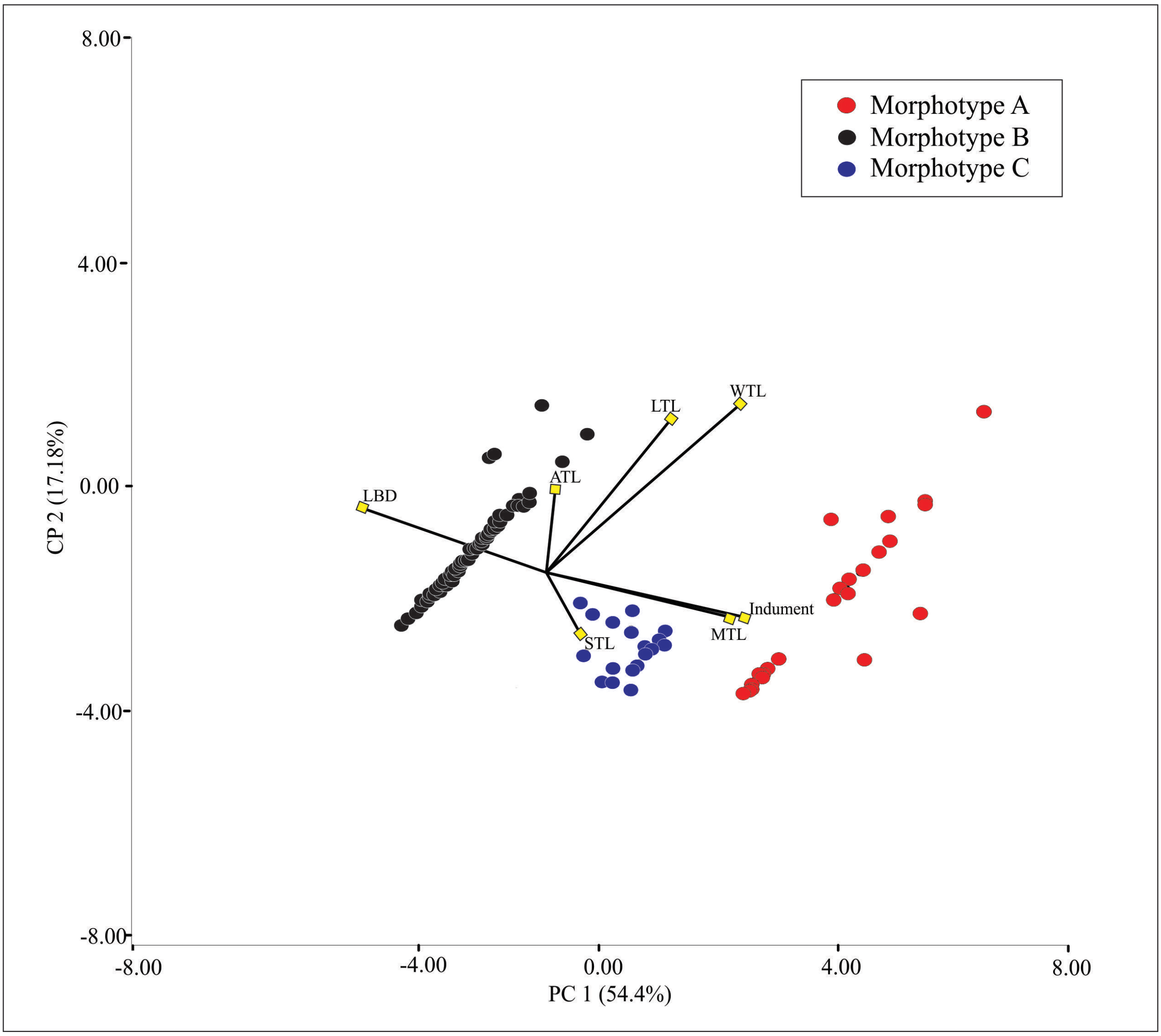

FIGURE 2. Ordination plot of the sample point in the plane of the first two component (PCA), indument and shape of the terminal leaflet defines two varieties, while the leaf blade dissection mainly defines the *S. perulacea* var. *krapovickasii* variety. Red circles: *S. perulacea* var. *perulacea*. Black circles: *S. perulacea* var. *krapovickasii*. Blue circles: *S. perulacea* var. *chacoensis*.

TABLE 3. Contribution of the morphological variables to the first two component. Values in bold indicates factor loadings with the highest weight at each component.

Variable	PC 1	PC 2
Leaf blade dissection	**-0.46**	0.33
Shape of the terminal leaflet	0.09	-0.24
Length of terminal leaflet	0.37	**0.57**
Width of terminal leaflet	**0.42**	**0.45**
Apex of the terminal leaflet	-0.03	0.38
Margin of the terminal leaflet	**0.50**	-0.24
Indument	**0.74**	-0.25

Geographical distribution:—Each of the three morphotypes is restricted to different geographic areas, with a partial overlap in only a few points (Fig. 3). The different morphotypes were never found in sympatry indicating they have habitat preference. The morphotype A mostly occurs in the Chiquitano Forest, in Central-East of Bolivia and Central-West of Brazil. This region is characterized by the presence of reddish soils, rich in iron, with a large dry station and long days with a great evaporation index (Hijmans *et al.* 2004). The morphotype B is the most widely distributed, growing from São Paulo in the Southeast of Brazil, to the Northwest of Argentina, with a small gap in Paraguay (Central-West of Presidente Hayes, Alto Paraguay and Boqueron departments) in which the morphotype C occurs. The morphotype B occurs in a variety of environments, exhibiting a great plasticity. Meanwhile, the morphotype C is circumscribed to a small region belonging to the Chaco plains of North of Argentina, Center-East of Bolivia (Cordillera province of the Santa Cruz department) and Western Paraguay, habitats with extremely low rainfall and clay soils.

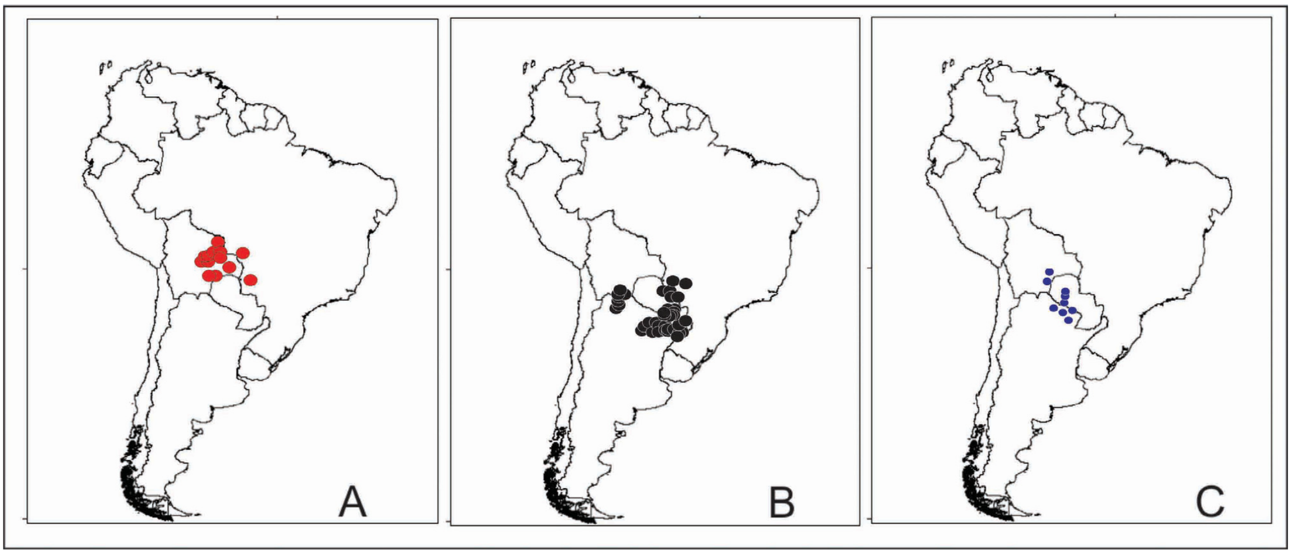

FIGURE 3. Distribution of the three morphotypes across *Serjania perulacea* range. A, Distribution of *S. perulacea* var. *perulacea* (morphotype A); B, *S. perulacea* var. *krapovickasii* (morphotype B); and C, Distribution of *S. perulacea* var. *chacoensis* (morphotype C).

The bioclimatic analyses also indicated that these morphotypes inhabit regions with different climatic regimes. The Table 2 summarizes the bioclimatic traits that characterize each morphotype. PCA of the bioclimatic data showed that the first two components accounted for the 58.2% of the total climatic variation (Fig. 4). The contribution of each variable to components 1 and 2 are shown in Table 4. Most of the variability of the bioclimatic data is explained by the first component (31.4%), and it relates to a major gradient in annual mean temperature, isothermality, mean temperature of wettest, driest and coldest quarter, and seasonal precipitation. Towards the negative values in this component is the morphotype B mostly linked to temperature seasonality, annual precipitation, precipitation of driest month, driest and coldest quarter, while the morphotypes A and C share a similar position in the axis. Also none of these morphotypes dispersed towards the negative values as occurred with the morphotype B.

TABLE 4. Contribution of the bioclimatic variables to components 1 and 2. Factor loadings with the higher contribution within each component are indicated in bold.

Variables	Component 1	Component 2
Annual mean temperature	**0.27**	**0.32**
Mean monthly temperature range	0.13	-0.24
Isothermality	0.3	-0.06
Temperature seasonality	**-0.3**	0.02
Maximum temperature of warmest month	0.01	**0.31**
Minimum temperature of coldest month	0.21	**0.36**
Temperature annual range	-0.21	-0.14
Mean temperature of wettest quarter	0.26	0.16
Mean temperature of driest quarter	**0.33**	0.2
Mean temperature of warmest quarter	0.03	0.34
Mean temperature of coldest quarter	**0.33**	0.25

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TABLE 4. (Continued)

Variables	Component 1	Component 2
Annual precipitation	**-0.24**	0.2
Precipitation of wettest month	0.01	-0.04
Precipitation of driest month	**-0.31**	**0.23**
Precipitation seasonally	**0.25**	**-0.33**
Precipitation of wettest quarter	0.03	-0.07
Precipitation of driest quarter	**-0.29**	**0.25**
Precipitation of warmest quarter	-0.05	-0.1
Precipitation of coldest quarter	**-0.26**	**0.26**

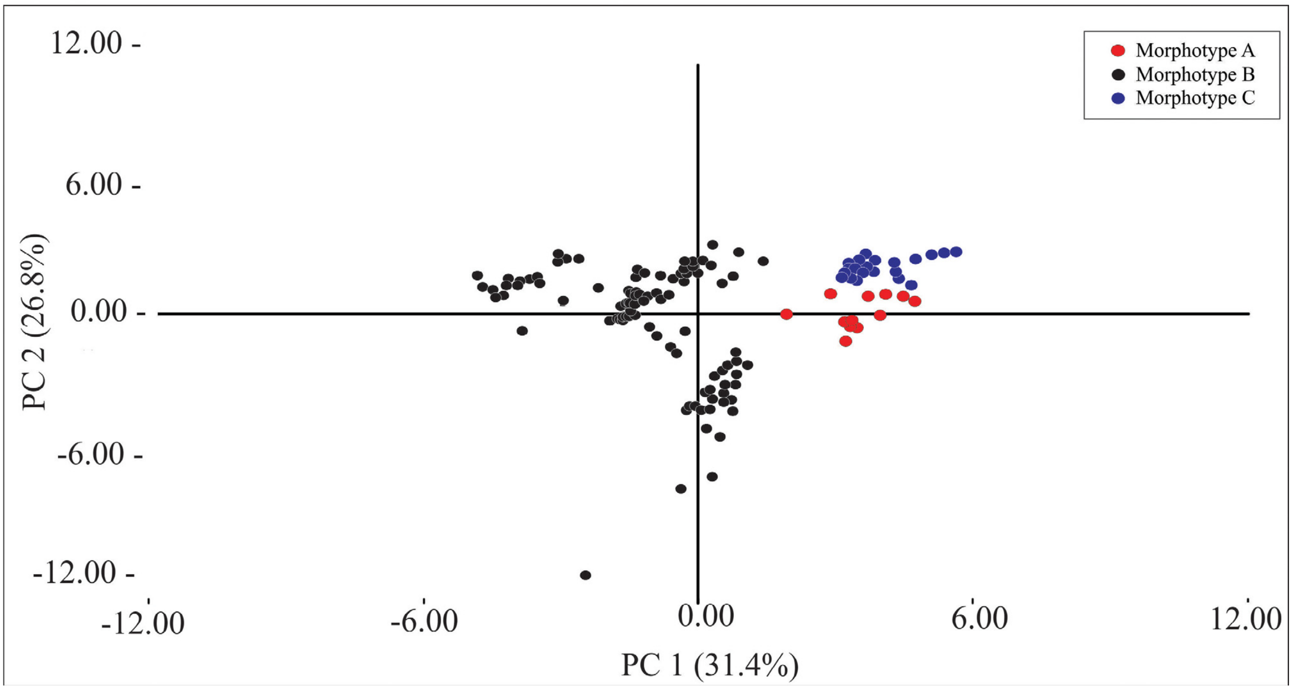

FIGURE 4. Principal component analysis of the bioclimatic data derived for each specimen of *Serjania perulacea* studied. Black circles: *S. perulacea* var. *krapovickasii* (morphotype B); red circles: *S. perulacea* var. *perulacea* (morphotype A), and blue circles *S. perulacea* var. *chacoensis* (morphotype C).

The second component explains the 26.8% of the remaining variation and it is closely related to annual mean temperature, maximum temperature of warmest month, minimum temperature of the coldest month, mean temperature of the warmest and coldest quarter, precipitation of the driest and coldest quarter. All these climatic conditions separate the morphotypes A and C.

Finally, results from the ordination based on morphological and bioclimatic data indicates that the three morphotypes show geographical exclusiveness. This was further supported by the climatic niche prediction that showed that each morphotype occurs in a discrete area delimited by bioclimatic conditions (Fig. 5).

Taxonomic treatment

From a taxonomic point of view, our results suggest that three morphotypes identified above represent varieties of *Serjania perulacea*. To formalize their taxonomic status we present here a complete description of the species and its varieties. In addition, a key to identify each variety is presented.

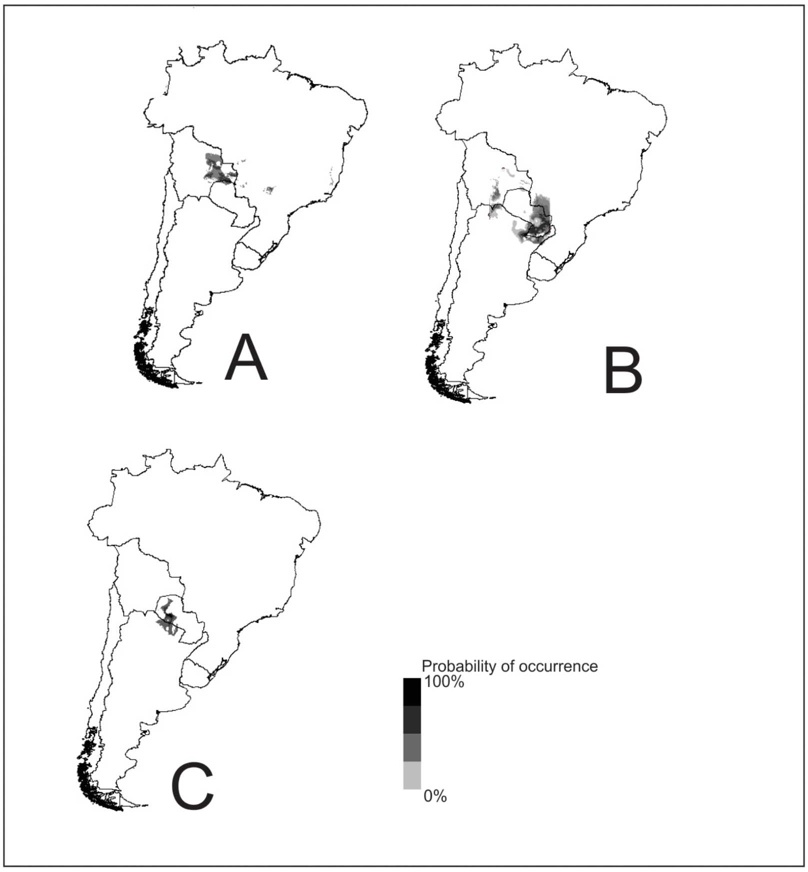

FIGURE 5. Predicted niche for *Serjania perulacea* and the new varieties. **A**. *S. perulacea* var. *perulacea* (morphotype A) with a niche restricted to Cerrado and Semideciduous Chiquitano Forest. **B.** *S. perulacea* var. *krapovickasii* (morphotype B) wide niche, from Brazil to Bolivia, with a gap in Paraguay. **C.** *S. perulacea* var. *chacoensis* (morphotype C) central-east of Paraguay.

Serjania perulacea **Radlk.** Consp. Sect. Sp. Serjan. 11. 1874.

Type:—BRAZIL: Minas Gerais, Inter Barra, corallinho et Rio Jequitaí, without date, *Pohl, J. B. E. 688* (Lectotype designated here: K 000037266!).

Woody vine, generally robust, monoecious, producing milky sap; pubescent, with indument of ochraceous short single trichomes, puberulous with whitish single trichomes or glabrous. Young branches, leaves, inflorescence axes, bracts and bracteoles, leaflets, and external sepals with simple, short, ochraceous trichomes. *Flowering branchlets* with 5 rounded ribs, cross section of stem with central, large vascular cylinder, and 3–5 peripheral vascular cylinders of different sizes, mostly elliptic-flattened, sometimes medulla partially hollowed. Stipules triangular, persistent, 0.5–2.5 mm long, pubescent. *Leaves* imparipinnate, 2–3-jugate, when 2-jugate, the lower jugae 3-foliolate, when 3-jugate, the lower jugae 3-foliolate or 2-jugate, 5-foliolate; petioles subterete, adaxially furrowed, 1.1–11.4 cm long; petiolules marginate, 0.5–4.0 cm long in terminal leaflet, in the proximal and distal pair of leaflets petiolules to 1.5 cm long or absent; leaflets chartaceous or subchartaceous, discolorous; terminal leaflet narrowly ovate, ovate, widely ovate, obovate or rare widely obovate, 1.7–17 × 0.9–12 cm; the other leaflets ovate or narrowly ovate, rarely obovate, 2.5–14.4 × 1.0–7.6 cm; apex acute, obtuse or retuse; base decurrent in terminal leaflet or acute in the proximal and distal leaflets; margins dentate-serrate, with 5–8 obtuse glandular teeth or with 7–10 acute glandular teeth, rare inciso-dentate; adaxial surface with veins slightly marked, with minute, curved, whitish trichomes, mid-vein with slightly longer pubescence and scattered bent glandular trichomes, abaxial surface pubescent with prominent veins or glabrous. *Thyrse* axillary, simple, racemiform; peduncle subterete, 2.5–10.4 cm long, pubescent, with 2 delicate tendrils at base; rachis subterete, striate, 4.5–12.5 cm long; cincinnus many-flowered, peduncle 6–11 mm long; pedicel 2–4.5 mm long, articulate near the base; in the fruits 3–4 mm long; bracts triangular, persistent, ca. 2 mm long, pubescent, bracteoles similar, 0.5–1 mm long. *Flowers* functionally staminate or pistillate, whitish, 6.5–9.6 mm long; sepals 5, ciliate, outer sepals wide ovate, obtuse, 3–4.5 × 1.7–2.5 mm, pubescent in both faces, inner sepals narrowly ovate, obtuse, 4.0–5.5 × 1.5–2.2 mm, pubescent in both faces; petals 4, obovate, clawed, erose, adaxially glandular, posterior ones broadly obovate, 4.5–5.5 × 2.0–3.0 mm, with symmetrical appendage, 3.5–4.5 × 1.0–2.0 mm, with crest erose and villous;

anterior petals with asymmetrical appendage, 4.0–6.0 × 1.5–3.0 mm; nectary lobes 4, the posterior ovate obtuse, the anterior ones ovate acute and smaller, glabrous; androgynophore glabrous or puberulous. Staminate flowers: stamens 4.0–5.5 mm long, filaments pilose; pistillode 0.5–1.7 mm long, glabrous. Pistillate flowers: sterile stamens 2.5–4.0 mm long, filaments flattened, pubescent, anthers indehiscent; gynoecium 5.5–7.0 mm long, ovary trigonous, obovoid in outline, pubescent (glandular and simple trichomes), and style straight, puberulous, 1.0–2.5 mm long, equal than the stigmatic branches. *Fruit* ovate in outline, chartaceous, brown, cordate at base, cocci inflated, dark brown, 0.8–1.5 × 0.6–1.0 cm wide, narrowly cristate, crest ca. 4 mm wide, emarginate at apex, not constricted at junction with wing; mericarp 1.9–3.0 × 1.2–1.8 cm; epicarp tomentosus on cocci, wings pubescent, endocarp woolly. *Seeds* trigonous obovoid in outline, ca. 0.45–0.7 × 0.3–0.5 cm, smooth, dark brown, basally attached. Embryo with abaxial cotyledon curved and adaxial cotyledon biplicate.

Distribution:—*Serjania perulacea* is known from southern South America, particularly in Argentina, Bolivia, Brazil and Paraguay.

Taxonomic notes:—The specimen designated as lectotype was chosen from amongst the material cited by Radlkofer (1875). It is a suitable specimen as it shows all the leaf traits that defines the species and it also present complete inflorescences.

Key to the varieties of Serjania perulacea

1. Vegetative organs ochraceous pubescent; leaflets chartaceous. Leaf blade imparipinnate 2-jugate, the lower jugae 3-foliolate. Terminal leaflet with the margin dentate-serrate with obtuse glandular teeth ....*S. perulacea* var. *perulacea*
1´. Vegetative organs glabrous or whitish puberulous; leaflets subchartaceous. Leaf blade imparipinnate 3-jugate, the lower jugae 3-5-foliolate or 2-jugate, 3–5-foliolate. Terminal leaflet with the margin dentate-serrate with acute glandular teeth or inciso-dentate.
2. Terminal leaflets 2.2–12 × 0.4–7.0 cm, narrowly ovate, apex acute, margin dentate-serrate with acute glandular teeth................... .... *S. perulacea* var. *krapovickasii*
2´. Terminal leaflets 1.8–4.7 × 0.4–3.9 cm, ovate or widely ovate or obovate, apex retuse, margin inciso-dentate with obtuse glandular teeth .... *S. perulacea* var. *chacoensis*

Serjania perulacea* Radlk. var. *perulacea (Fig. 6)

Robust woody vine, ochraceous pubescent, indument in vegetative and reproductive organs. Leaves imparipinnate, 2–jugate, the lower jugae 3–foliolate; leaflets chartaceous, terminal leaflet ovate, wide ovate or obovate, 3–17 × 2.4–12 cm; apex obtuse mucronate, rare retuse; base decurrent in terminal leaflet or acute in the others; margin dentate-serrate, with 5–8 inconspicuous obtuse glandular teeth.

Distribution:—*Serjania perulacea* var. *perulacea* occurs in Bolivia (department of Santa Cruz) and Brazil (States of Goiás, Minas Gerais and Mato Grosso). In Bolivia this variety grows in the Cerrado and in the Chiquitano semi-deciduous forest vegetation. In Brazil it grows in the Bosque Estacional Semidecidual (Cerrado, Cerradão). Both areas are characterized by reddish soils.

Phenology:—Flowering between July and September, and fructify in October.

Representative specimens examined:—BOLIVIA: Santa Cruz: June 1847, sterile, *M. F. Castelnau 103* (P 02296815!); Prov. Chiquitos: 1.2 km de Chochis, camino al Santuario, 18°08´23´´S, 60°02´20´´W, 08 August 2010, fl, *J. P. Coulleri et al. 41* (CTES); Reserva Natural de Valle de Tuca Vaca, 18°19´31´´S, 59°34´48´´W, 09 August 2010, fl, *J. P. Coulleri et al. 48* (CTES); Prov. Ñuflo de Chavez, 12 km W de San Javier, camino a San Ramón, 16°18´30´´S, 62°30´39´´W, 05/August2010, fl, *J. P. Coulleri et al. 4* (CTES); 11.6 km N de San Javier, camino a la curtiembre, 16°76´22´´S, 62°32´40´´W, 05/August 2010, fl, *J. P. Coulleri et al. 11* (CTES); 20 km N de San Ramón, camino a San Javier, 16°28´08´´S, 62°29´25´´W, 20/July 2003, fl, *M. S. Ferrucci et al. 1874* (CTES); Concepción, 3-4 km al sur, camino a Lomerio, 09/September 1994, fl, *B. Mostacedo & S. V. Dahlberg 2381* (CTES, USZ); Prov. Velasco: 67 km E de Concepción, camino a San Ignacio, 15°51´29´´S, 61°37´06´´W, 06/August 2010, fl, *J. P. Coulleri et al. 20* (CTES); 22 km N de San Rafael, 16°35´00´´S, 60°42´55´´W, 07/August 2010, fl, *J. P. Coulleri et al. 25* (CTES); 54 km N de San José de Chiquitos, camino a San Rafael, 17°20´52´´S, 60°40´15´´W, 07/August 2010, fl, *J. P. Coulleri et al. 29* (CTES, G, SI); 34 km S de San Rafael, camino a San José de Chiquitos, 17°03´18´´S, 60°36´29´´W, 07/April 2009, sterile, *M. Dematteis et al. 3581* (CTES); Reserva Biológica El Refugio, camino al S del campamento La Toledo pasando por bosque seco y pampa con *Mauritiella*, 14°43´34´´S, 61°09´33´´W, 09 October 1995, fr, *P. F. Foster 313* (CTES, MO). BRAZIL: Goiás: Municipio de Alvorada do Norte, 20 km a NE da cidade, 23/July 1971, fl, *I. Gottsberger & G. Gottsberger 23-23771* (ULM). Mato Grosso: Estação Ecologica Serra das Araras (mun. Porto Estrela), 24/ October 1995, fr, *G. Hatschbach et al. 63833* (CTES, MBM); Minas Gerais: in sepibus campestribus deserti ad fluv. St. Francisco, fl, *C. F. P von Martius s.n.* (M 0212403!); Lagoa Santa, fl, *E. Warming s.n.* (BR 0000005908608!, M 0212404!); Mato Grosso: inter Barra, Corallinho et Rio Jequetay [=Rio Jequitaí], fl, *J. B. E. Pohl* 688 (F 0071801F!, NY 01546718!).

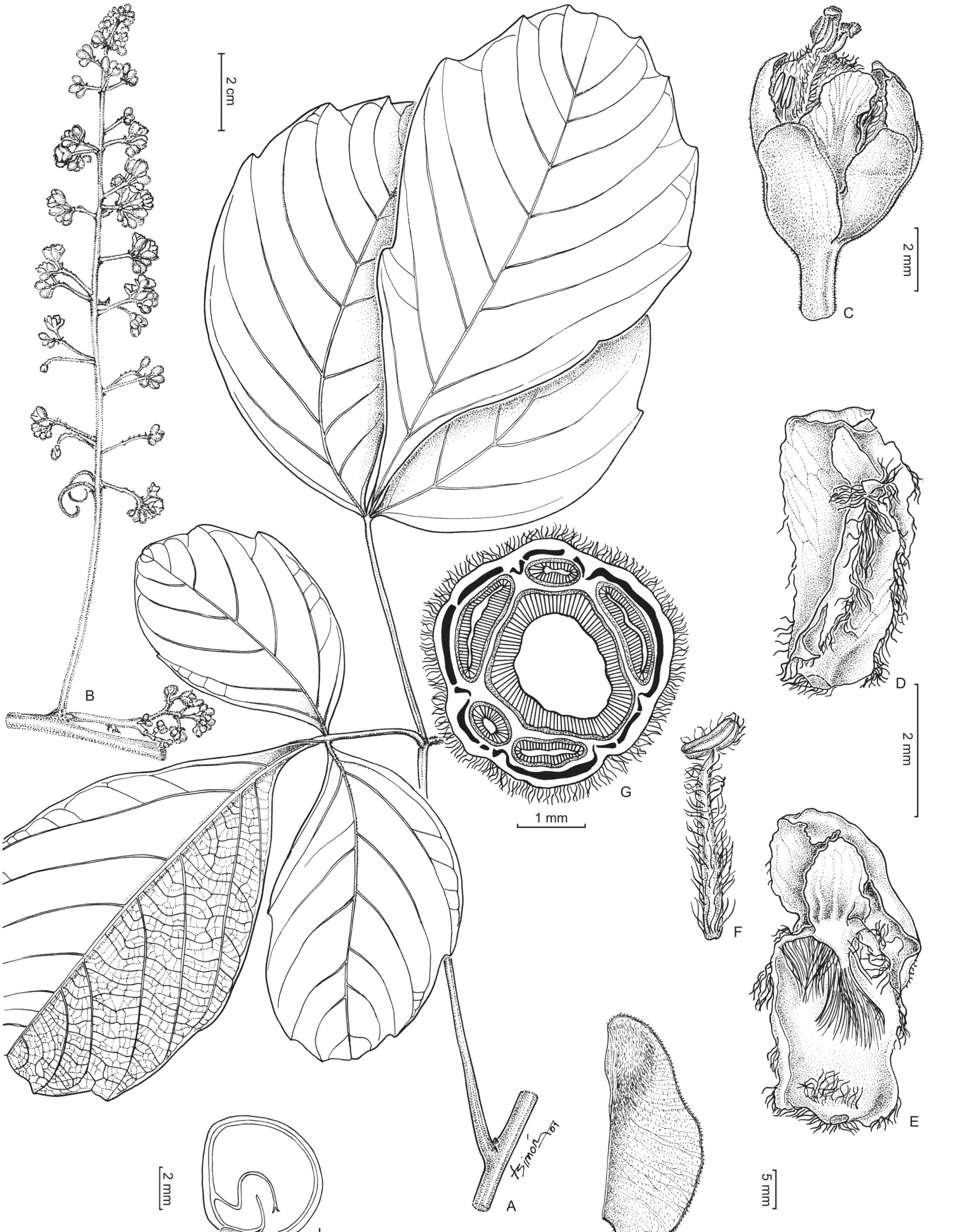

FIGURE 6. *Serjania perulacea* var. *perulacea*. **A**. Vegetative branch. **B**. Inflorescence. **C**. Pistillate flower. **D**. Anterior petal with adnate appendage. **E**. Posterior petal with adnate appendage. **F**. Stamen of a pistillate flower. **G**. Cross section of the stem. **H**. Mericarp. **I**. Seed in longitudinal section. [A–G. *Gottsberger, I. & Gottsberger, G.23-23771* (ULM); H–I. *Hatschbach et al. 63833* (CTES)].

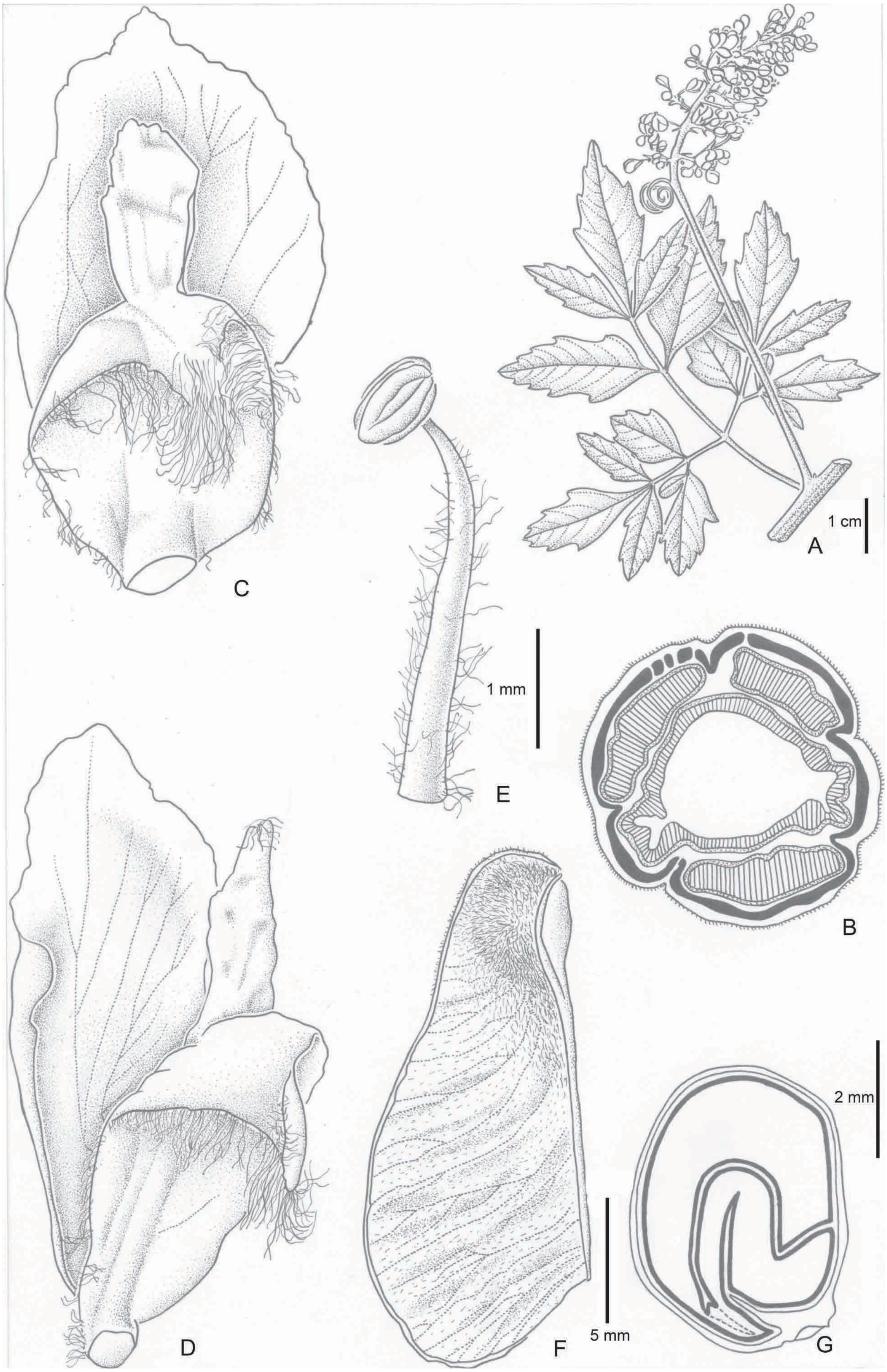

FIGURE 7. *Serjania perulacea* var. *krapovickasii*. **A.** Flowering branch. **B.** Cross section of the stem. **C.** Posterior petal with adnate appendage. **D.** Anterior petal with adnate appendage. **E.** Stamen of a staminate flower. **F.** Mericarp. **G.** Longitudinal section of the seed. [A, E. *Schinini 11589* (CTES); B–D. *Ferrucci 30* (CORD, CTES, LIL, LP); F, G. *Krapovickas et al. 26453* (CTES)]. (Previously published in Flora del Paraguay 16:108. 1991).

Serjania perulacea* Radlk. var. *krapovickasii Coulleri & Ferrucci (Fig. 7)

= *Serjania meyeri* F. A. Barkley, Lilloa 28: 118. 1957. Type: ARGENTINA. Chaco, Fontana, 10/1938, fr, *Meyer, T. 3307* (LIL!).

Type:—PARAGUAY: Assumption [Asunción], June 1858, fl, *Gilbert 63* (holotype: K 000037264!)

Diagnosis:—*Serjania perulacea* var. *krapovickasii* is a woody vine distinguished from ***S. perulacea* var. *perulacea*** by the absence of indumenta, leaflets subchartaceous, smaller and with margin dentate-serrate with acute teeth.

Woody vine, glabrous. Leaves imparipinnate, 3–jugate, the lower jugae 2 jugate, 3–5–foliolate; leaflets subchartaceous; terminal leaflet narrowly ovate, 2.2–12 × 0.4–7.0 cm; apex acute although less frequent obtuse-mucronate; base decurrent in terminal leaflet or acute in the proximal and distal leaflets; margin dentate-serrate with 7–10 conspicuous acute teeth.

Distribution:—*Serjania perulacea* var. *krapovickasii* is known in the Chuquisaca, Santa Cruz and Tarija departments, in Bolivia; Goiás, Minas Gerais, Mato Grosso, Mato Grosso do Sul and São Paulo states, in Brazil; and Alto Paraguay, Amambay, Boquerón, Capital, Cordillera, Ñeembucú, Paraguarí, Presidente Hayes and San Pedro departments, in Paraguay. This variety occurs mainly in the wet and dry Chaco.

Phenology:—Flowering between June and October, and fruiting between September and October.

Etymology:—This variety is named in honor of Dr Antonio Krapovickas who was the Director of the Instituto de Botánica del Nordeste between 1977 and 1991. Dr Krapovickas constantly supported our scientific work and always provided wise advice on taxonomy, nomenclature and life in general.

Representative specimens examined:—ARGENTINA: Chaco: Dep. 1° de Mayo, Estancia Varela, San Miguel, 22/ January 1954, sterile, *A. G. Schulz 7336* (CTES). Corrientes: Dep. Capital, Perichón, 29/September 1974, fr, *A. Krapovickas et al. 26453K* (CTES); Balneario Molina Punta, 22/August 1978, fl, *M. S. Ferrucci 30* (CTES); *ibidem,* 21/August 1975, fl, *A. Schinini 11589* (CTES). Formosa: Dep. Pirané, El Colorado, Paraje, estación experimental Ag. INTA, September 1971, fr, *P. Insfrán 889* (CTES). Jujuy: Dep. Ledesma, Parque Nacional Calilegua, 21/September 1997, fr, *M. Dematteis & G. Seijo 818* (CTES). Misiones: Dep. San Javier, acceso hacia Cerro Monje, 27°51´11,3´´S, 55°7´42´´W, 26/July 2008, fl, *H. Keller 5659* (CTES). Salta: Dep. Orán, Camino a Isla de Cañas, 10-30 km al W de ruta 50, ribera N del Río Iruya, 25/October 1991, fl, *L. Novara et al. 10413* (CTES). BOLIVIA: Chuquisaca: Luis Calvo, Serranías de Incahuasi, Abra de Incahuasi, 19°48´52´´S, 63°43´10´´W, 17/October 2005, fl, *A. Lliully et al. 352* (CTES, MO). Santa Cruz: Ibañez, 4.7 km SE de Bermejo, camino a El Torno, 18°09´37´´S, 63°36´14´´W, 12/ August 2010, sterile, *J. P. Coulleri et al. 59* (CTES); Tarija: Gran Chaco, Yacuiba, 18-24 km hacia Palos Blancos, 24/ September 1985, fl, *S. Beck et al. 11548* (CTES). BRAZIL: Mato Grosso do Sul: Município de Porto Murtinho. Estrada entre Caracol e Porto Murtinho, cerca de 84 km de Caracol, 20°45´S, 57°33´W, 11/August 2001, fl, *V. C. Souza et al. 26799* (CTES, ESA). PARAGUAY: Assumption [Asunción], June 1858, fl, *Gilbert 63* (K 000037264). Amambay: Bella Vista, Río Apa, 25/August 1980, fl/fr, *A. Schinini & E. Bordas 20637* (CTES). Capital: Pto. Itá Enramada, 06/September 1976, fl/fr, *A. Schinini & E. Bordas 13348* (CTES). Central: Tavarory, Río Paraguay, 25°28´20´´S, 57°33´03´´W, 17/July 1995, fl, *L. R. Landrum et al. 8570* (CTES). Cordillera: Cerro Tobatí, 02/October 1987, fr, *E. Zardini & R. Degen 3503* (CTES). Itapúa: Encarnación, Mboicae, 21/September 1949, fl, *L. Bertoni 4465* (CTES). Misiones: Ruta 1 en inmediaciones de San Ignacio, 17/August 1980, fl, *M. S. Ferrucci 167* (CTES). Ñeembucú: Estancia Luis Rodas, camino a Rincón de Luna, 27°03´15´´S, 57°46´41´´W, 24/August 2004, fr, *C. Vogt 136* (CTES, FCQ, UMA). Paraguarí: Macizo Acahay, 25°54´S, 57°09´W, 03/September 1988, fl, *E. Zardini & T. Florentín 6951* (CTES). San Pedro: V. Primavera, 26/July 1958, fl, *A. Woolston 1009* (CTES, SI).

Serjania perulacea* Radlk.var. *chacoensis Coulleri & Ferrucci (Fig. 8)

Type:—PARAGUAY: Boquerón: Filadelfia, 07/10/1979, fl, *Schinini A. & Bordas E. 18165* (holotype: CTES! isotypes: C!, CORD!, MBM!, MO!).

Diagnosis:—*Serjania perulacea* var. *chacoensis* is a glabrous or whitish puberulous vine that differs from the other two varieties by the color of the pubescence and the inciso-dentate margin of the leaflet with obtuse glandular teeth.

Woody vine, glabrous or whitish puberulous, trichomes single and short, mainly in the abaxial face of the leaflets. Leaves imparipinate, 3-jugate, the lower jugae 3-5-foliolate or 2-jugate, 3-5-foliolate, leaflets subchartaceous; terminal leaflet ovate, wide ovate or obovate; 1.8–4.7 × 0.4–3.9 cm; apex retuse; base decurrent in terminal leaflet or acute in the others; margin inciso-dentate with 5–7 conspicuous obtuse glandular teeth.

Distribution:—*Serjania perulacea* var. *chacoensis* is distributed in Chaco and Formosa provinces, in Argentina; in Santa Cruz department, in Bolivia; and Boquerón and Presidente Hayes departments in Paraguay. This variety occurs mainly in dry Chaco.

Phenology:—Flowering between August and November, and fruiting between October and November.

Etymology:—The name of this variety refers to the habitat it occupies.

Representative specimens examined:—ARGENTINA: Chaco: Dep. General Güemes, 2 km al E de la Invernada por el camino que bordea al río Teuco, 19°S, 61°46´W, 04/March 2000, sterile, *R. Fortunato et al. 6578* (BAB, CTES). Formosa: Dep. Patiño: 4 km del Puesto de Gendarmería San Ramón, por ruta a Misión Tacoagle, direcc. S., 16/November 1991, fl, *R. Fortunato et al. 2378* (BAB, CTES); Fortín Sargento 1° Leyes, Ea. Pozo del Ciervo, Río Pilcomayo, 05/August 1981, fl, *J. J. Valla et al. 120* (BAA, CTES). BOLIVIA: Santa Cruz: Prov. Cordillera: Boyuibe, 55 km hacia la frontera paraguaya vía F. Villazón, 04/October 1983, fr, *S. Beck & M. Liberman 9420* (CTES, LPB); Aguarati Izozog, 19,15536°S, 62,28290°W, 13/ June 1998, sterile, *G. Bourdy 2024* (CTES, USZ); Cuarirenda Izozog, 500 m al norte de la comunidad Cuarirenda, 15/September 1998, fl, *G. Bourdy 2032* (CTES, USZ); Cuarirenda, 19°05´S, 62°29´W, 10/October 1992, fr, *M. Villegas & R. Manchego 221* (CTES, USZ). PARAGUAY: Boquerón: Colonia Fernheim, Colonia 22 (Neuwiese), 08/November 1987, fr, *P. Arenas 3306* (BACP, CTES); ibidem*,* 09/September 2003, fl, *L. August 75* (CTES); *ibidem*, 01/October 1999, sterile, *L. August 363* (CTES); *ibidem,* 06/October 1998, fl, *J. Friesen 27* (CTES); *ibidem*, 25 km de Filadelfia, camino a Fortín Tte. Montanía, 22/August 1981, fl, *A. Schinini et al. 21081* (CTES); *ibidem*, 15/June 1986, sterile, *N. Soria 1244* (CTES, FCQ); Neuland, Parque Valle Natural, 22°34´S, 60°06´W, 18/January 1993, sterile, *L. Pérez et al. 2741* (CTES, PY). Presidente Hayes: Colonia Meno, Misión Nueva Vida, 02/February 1976, sterile, *P. Arenas 1523* (CTES); *ibidem,* Loma Plata, 12/November 1990, fl, *R. Vanni et al. 1937* (CTES).

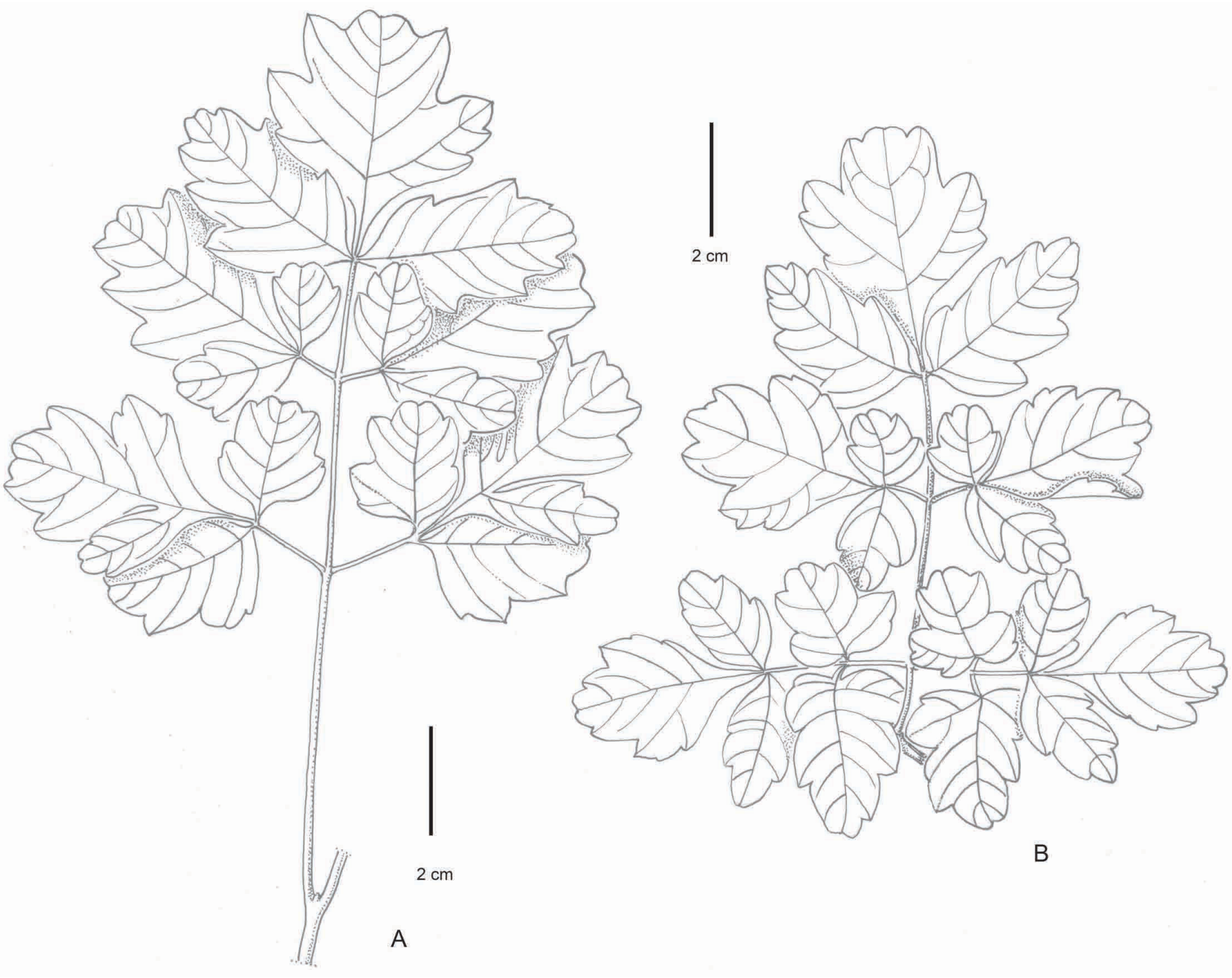

FIGURE 8. *Serjania perulacea* var. *chacoensis*: **A.** Leaf blade imparipinnate 3-jugate, 3-foliolate the lower jugae. **B.** Leaf blade imparipinnate 3-jugate, 5-foliolate the lower jugae. [A. *Soria 1244* (CTES); B. *August 363* (CTES)].

Discussion

The multivariate analysis of the morphological data recognized three morphotypes, one of them is the typical form of *Serjania perulacea,* while the other two are morphotypes that we recognized here as two different varieties. These varieties can be recognized by leaf traits that do not overlap. These traits could be the result of the adaptation to specific environmental conditions (see Gould & Johnston 1972, Linhart & Grant 1996). Indeed our results suggest that environmental conditions such as humidity, incidence of solar radiation and rainfall can influence the distribution of each variety. If this climatic data are considered at regional scale, it can be assumed that the scarcity of soil water resources and/or the high evaporative demand of the atmosphere during the warmer seasons would induce stress. Survival to these adverse conditions will require long- and short-term plastic responses and plants may develop a stress avoidance mechanism by modifying the canopy architecture (Save *et al*. 1995) or leaf heterogeneity (Niinemets 1996).

Environmental conditions have driven phenotypic divergence within *S. perulacea* and promoted leaf heterogeneity, in particular. For instance, if pubescence has ecological significance, its occurrence should indicate how the environment has acted to arrange the genetic material that regulates its production. A good example of this are the populations of *S. perulacea* var. *perulacea* and *S. perulacea* var. *krapovickasii.* The first variety, from a dry habitat, bears a dense ochraceous pubescence, whereas the populations of the second variety, mostly inhabiting a humid habitat, is always glabrous. This interpretation is further supported by the early views of Kerner von Marilaun (1896), Schimper (1903), Warming (1909), Coulter *et al*. (1911), and Sabnis (1919), who proposed that pubescence is positively associated with harsh moisture regimes, and in cases where species exist in both xeric and mesic habitats the individuals from the xeric habitat are the most hairy.

Similarly, differences in leaf blade dissection, size and grade of incision of the leaflet margin observed among the three varieties can be attributed to local environmental conditions. Parkhurst & Loucks (1972) indicates that such changes, for instance, have been linked to the prevailing climatic conditions. In fact, leaf morphoanatomical plasticity in response to combined conditions of incident irradiance, air temperature and humidity is one of the features that confer success to many plant species (Klich 2000). Changes in leaf size were observed in our study and these could have an adaptive significance. For instance, populations *S. perulacea* var. *perulacea* with bigger size leaves occur in environments with high temperature and relatively dry, such the Chiquitano forest in Bolivia, which is a seasonally dry forest *sensu* Pennington *et al.* (2000). Meanwhile, *S. perulacea* var. *chacoensis* grows in Western Paraguay, Chaco plains, and its leaves are in accordance with the expected for plants that inhabit places with a high index of evaporation due by high temperatures and a low rainfall regime. Whereas, *S. perulacea* var. *krapovickasii* (morphotype B), bears a wide range of leaves sizes, in accordance with the wide range of environmental conditions in which this variety grows. Dissection of the leaf margin in *S. perulaceae* follows the same logical argument given by Parkhurst & Loucks (1972). Thus, a deepest incision grade reduces the foliar surface, avoiding dehydration in high incidence of solar radiation. This matches with the phenotype of *S. perulaceae* var. *chacoensis* from drier habitats.

Conclusion

Serjania perulacea is a morphologically variable species. Three varieties have been recognized mainly based on differences in the indumentum, color and its presence in the vegetative organs, the division of the leaf blade and the shape, apex and margin of the terminal leaflet. These differences suggest a strong response to the environment that results in morphotypes with exclusive geographical distribution. To further understand the process of diversification within *Serjania perulacea* population genetics and gene flow studies are required using either DNA sequencing techniques or genotyping methods such as microsatellites or AFLP.

Acknowledgements

We thank Laura Simón for preparing the excellent illustrations, as well as Gelina Pieszko for digitizing the images. This work was supported by the Agencia Nacional de Promoción Científica y Tecnológica (PICTO-UNNE, FONCyT 2011-0202), the Consejo Nacional de Investigaciones Científicas y Tecnológicas (CONICET) and the Universidad Nacional del Nordeste (SGCYT PI A012-2013, PI15-P001).

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