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Is the variation of floral elaiophore size in two species of *Stigmaphyllon* (Malpighiaceae) dependent on interaction with pollinators?

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Background: Intraspecific variations in floral traits of species over its geographic range can be associated with differences in pollinator assemblages and/or with environmental conditions.
Aims: We evaluated the area of elaiophores in different populations of *Stigmaphyllon bonariense* (n = 9) and *S. jatrophifolium* (n = 6), and we hypothesised a marked reduction in their size towards their southern limits of distribution, associated with different oil-collecting bee assemblages.
Methods: Area of elaiophores was calculated and we carried out linear correlations with floral size, pollinators, visitation rate and pollinator size along the latitudinal gradient of the plants' distributions. Moreover, we examined the relative size relationships using allometric analyses, to verify this reduction.
Results: Floral elaiophore area decreased with latitude. However, for *S. bonariense* we observed an allometric reduction in elaiophore area with respect to floral size, while for *S. jatrophifolium* an isometric reduction was found. In both species, pollinator richness and visitation rate did not diminish with latitude, but pollinator size for *S. bonariense* varied.
Conclusions: Our results show a reduction in the size of elaiophores in both species along their distribution range, with dissimilar tendencies, suggesting that these species may have different selection pressures that cause variation of their phenotypic traits.

Keywords: elaiophore; flower-bee interaction; Malpighiaceae; oil-collecting bees; oil-rewarding flowers

Introduction

Intraspecific variation in floral traits is important for identifying the role of adaptive evolution in floral diversification (Hodgins and Barrett 2008), and pollinators have played a crucial role as partners in the diversification of angiosperm flowers (Herrera et al. 2006). Most animal-pollinated flowers have attractive organs (e.g., petals) and rewarding structures (e.g., elaiophores: structures that produce floral oils). Petals (or perianth) may have evolved to increase the number of pollinator visits (Ushimaru and Nakata 2001) and to determine the type of pollinator which visits them; moreover, flowers with higher quantities of reward may satisfy larger pollinators (Cohen and Shmida 1993). In plants with a wide distribution, floral traits related to adaptation to local pollinator fauna may vary in a mosaic fashion (Olsson and Ågren 2002; Thompson 2005). The geographic mosaic theory states that species interactions vary within space, exhibiting geographic selection mosaics (Giannini et al. 2013) and that interactions made by a species in great part depend on local conditions, for instance partner availability and local fitness (Mello et al. 2013). However, these changes can also be explained by abiotic gradients (Barrett et al. 2004). For example, in *Calceolaria polyrhiza* Cav. (Calceolariaceae), an oil-rewarding species, some studies have shown that mainly changes in pollinators, and lesser so climatic and edaphic conditions, were related to the variation of the floral reward composition at the geographic scale (Cosacov et al. 2012; 2014).

In the Neotropical region, most species of Malpighiaceae have elaiophores, and floral oil is collected by females (and some males) of numerous species of bees for nest construction and protection and/or mixed with pollen mass for larval food (Vinson et al. 1996). This pollination system is highly specialised and species of this family are effectively pollinated by a low diversity of bees, principally species of the oil-collecting genera *Centris* (Figure 1(a)), *Epicharis* (Apidae: Centridini, following the nomenclature of Michener 2007) and *Monoeca* (Apidae: Tapinotaspidini). However, some species lack elaiophores, or these glands can be reduced or absent in different populations of a particular species (Anderson 1979; Cappellari et al. 2011) or even show intra-individual variations (Sazima and Sazima 1989). Carvalho et al. (2005) have commented that the size of the elaiophores and the quantity of oil produced were positively correlated. On the other

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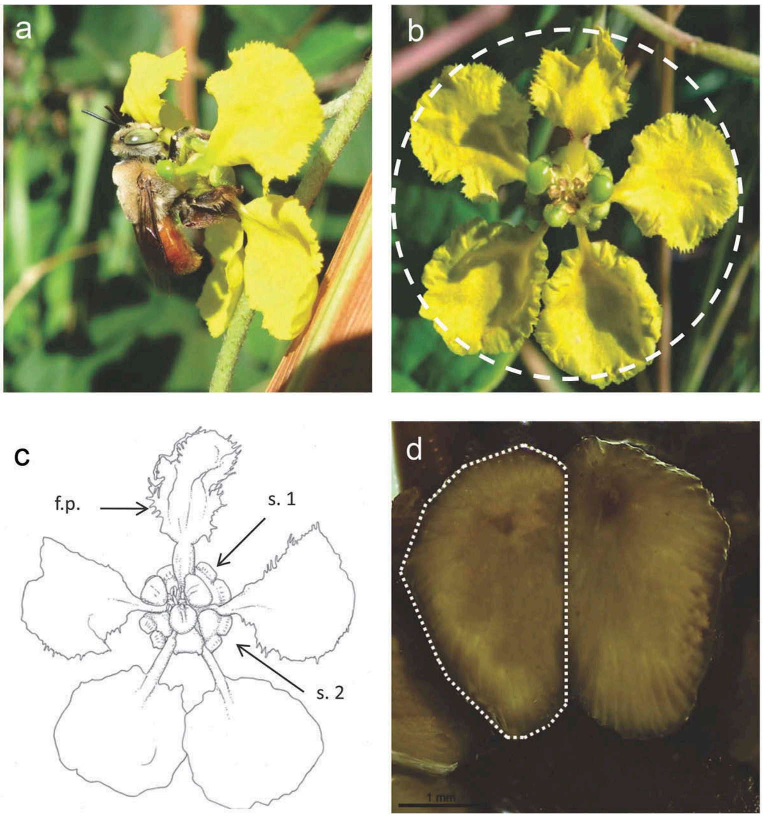

Figure 1. *Stigmaphyllon bonariense*. (a) *Centris trigonoides* female gathering oils with its fore- and mid-legs from the elaiophores (note the female grasping the base of flag petal with its mandibles and scraping the elaiophores). (b) Floral diameter (in frontal view) as proxy of size floral. (c) Schematic diagram of a flower showing flag petal (f.p.) and elaiophores in right sepal 1 (s.1) and sepal 2 (s.2). And (d) polygon drawing on perimeter of one elaiophore to calculate its area.

hand, shifts in the pollination system in which floral oil is being lost and pollen is becoming the main reward were corroborated in *Pterandra pyroidea* A. Juss. or presumed in Old World species of Malpighiaceae (Cappellari et al. 2011).

In Argentina, plant species diversity decreases markedly southwards with few species reaching 35°–40° S and there is a large turnover associated with latitude. Similar patterns of distribution are observed in oil-collecting bees associated to Malpighiaceae (Roig Alsina 2000; Moure et al. 2007; Torretta and Roig Alsina 2016). It is conceivable that elaiophore size in plants would diminish towards higher latitudes and that there would be a difference in pollinator assemblages from north to south.

We evaluated this hypothesis in *Stigmaphyllon bonariense* (Hook. & Arn.) C.E. Anderson and *S. jatrophifolium* A. Juss. along their latitudinal distribution in Argentina. We predicted that (a) the size of the rewarding structure (total elaiophore area per flower) varied more than the size of the attraction organs (floral size), being smaller in the southernmost populations (allometric hypothesis), and (b) oil-collecting bee assemblages would be less rich, have lower visitation rate, and/or the body size of bees would be smaller in populations closer to the southern limits of the distribution of the two plant species, compared to their northern populations.

Materials and methods

Species and populations studied

S. bonariense and *S. jatrophifolium* are woody perennial vines with yellow flowers, arranged in pseudo-umbels (20–30 flowers per inflorescence, but only 2–3 synchronously opened), solitary or borne in dichasia (Múlgura de Romero 2005, see line 473). Natural populations (n = 9 for *S. bonariense* and n = 6 for *S. jatrophifolium*) were selected in different sites of north-eastern Argentina (Figure 2) along a latitudinal gradient that extends across different types of vegetation belonging to diverse phytogeographic provinces, based on the classification of Cabrera (1971) for Argentina. These areas include tropical rain forests, riverine forests, lowland forests, palm groves, floodplains, public parks and other modified environments, with different richness of co-flowering species of Malpighiaceae (Table 1). Sampling was carried out during four consecutive years, but not all sites were visited on each occasion (December/February 2013/2014, 2014/2015, December 2015 and December/April 2016/2017 Table 1). Each visit consisted of 1–3 days of floral collection and censuses of pollinators.

Fresh flowers were obtained from plants from natural populations. We collected between 10 and 50 flowers in anthesis of each studied individual (n = 2–5) and the fresh material was fixed in formalin-acetic acid-alcohol mixture

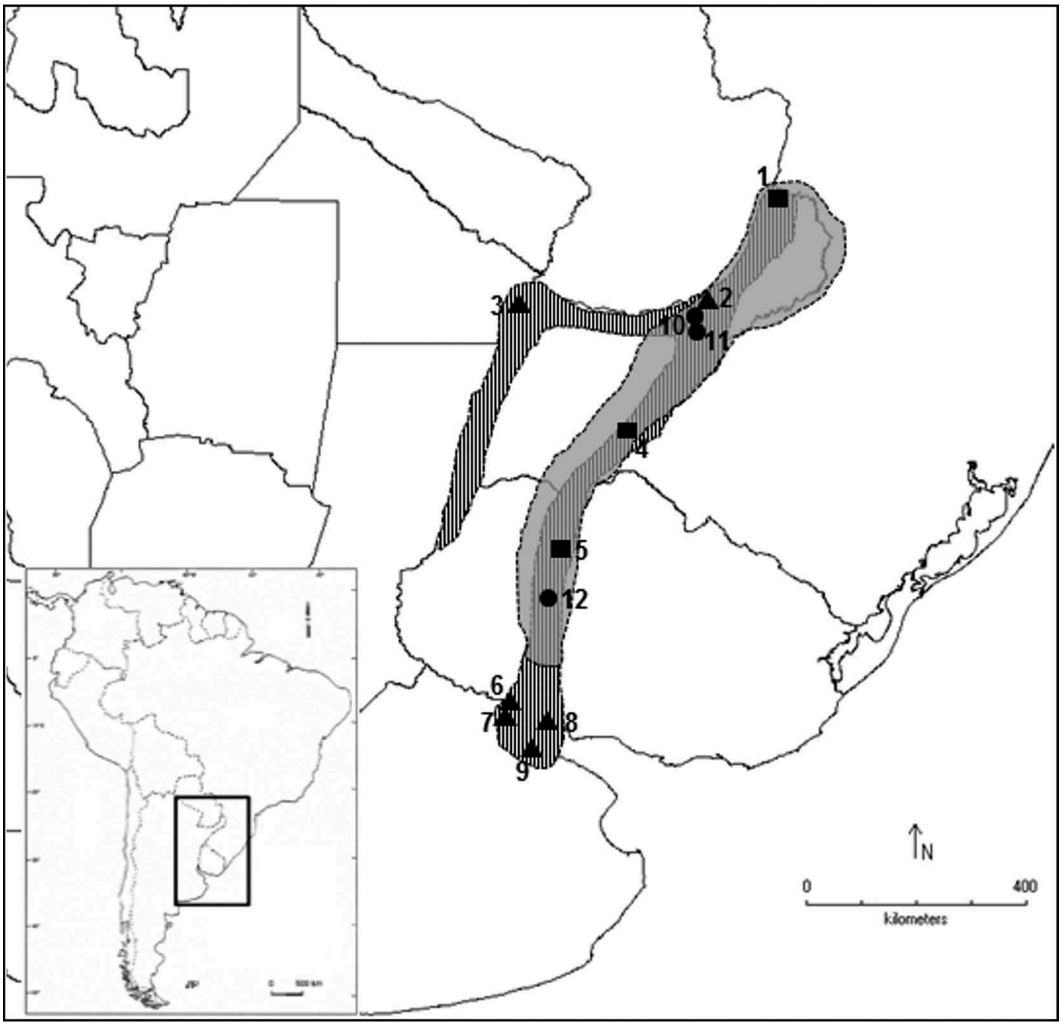

Figure 2. Distribution area in Argentina of the two species and the distribution of the studied populations of *Stigmaphyllon bonariense* (area with vertical lines and triangles) and *S. jatrophifolium* (grey area and circles); both species in same locality (squares). Population numbers correspond to those in Table 1.

for 48 h and stored in 70% alcohol. The reference vouchers were deposited in the herbaria of the Agronomy Faculty, Buenos Aires University and Darwinion Institute, Buenos Aires (SI).

Climate data (annual mean temperature and precipitation) were provided by the National Meteorological Service of Argentina for the period 1981–2010, except for Martín García Island (period 1961–1991). When climatic data for a particular locality were unavailable, we used information from the nearest weather station (Table 1).

Floral size and total area of elaiophore per flower

For each population, flowers (n = 10) in complete anthesis were selected and observed using a stereomicroscope in the laboratory. The diameters of the flowers were measured (Figure 1(b)) to estimate floral size. Later, we counted the number of elaiophores per flower and took digital photographs with a camera incorporated in an optical microscope (in frontal view, all with same magnification to ensure that photographs were comparable) of the elaiophores from the two sepals to the right of the flag petals of each flower (Figure 1(c)). The photographs were used to calculate the area of each elaiophore (Figure 1(d)), drawing the perimeter of each elaiophore and calculating the surface area of these polygons using the Motic Images Plus 2.0 ML software (function: Area). To estimate total area of elaiophore per flower, we summed the calculated areas and multiplied them by two to include the left-side sepals. In exceptional cases, the number of elaiophores per flower was different from eight; for these cases the total area was corrected accordingly.

Assemblages of potential pollinators and floral visitors

We observed and captured species of oil- and pollen-collecting bees across populations on different days (2–6 days per population, except for Cerro Corá [population No. 10, in Figure 2] which was during just 1 day) and at different times of the day (between 8:00 and 19:00 h). We conducted censuses of a duration of 10 min on a known number of flowers (cumulative time = ca. 30–180 min per population, Table 1) and we captured all floral visitors. With this data,

Table 1. Description of the study sites in Argentina.

Population: number – province – locality (geoposition)	Sampling date	Sampling effort (min)	Annual mean temperature (°C)	Annual mean precipitation (mm)	Vegetation type/land use	Richness of co-flowering species of Malpighiaceae
Stigmaphyllon bonariense						
1– Misiones – Iguazú (S 25°40′, W 54°27′)	December 2014 December 2015 March 2017	180	21.7	1950.5	Rain forest, in National Reserve	9
2 – Misiones – San Ignacio (S 27°17′, W 55°35′)	December 2014 December 2015 January 2017	150	22.2[a]	1867.5[a]	Rain forest, in Province Reserve	12
3 – Corrientes – Corrientes (S 27°22′, W 58°41′)	December 2015 February 2017 April 2017	150	21.8	1521.3	Riverine forest, in public park	5
4 – Corrientes – Yapeyú (S 29°28′, W 56°49′)	December 2013 December 2014	40	20.2[b]	1555.1[b]	Riverine forest, in public park	5
5 – Entre Ríos – Concordia (S 31°22′, W 57°59′)	December 2014 January 2017	90	19.1	1371.6	Riverine forest, in public park	3
6 – Entre Ríos – Ibicuy (S 33°53′, W 58°52′)	February 2014	30	18.1[c]	1136.4[c]	Riverine vegetation of public use	1
7 – Buenos Aires – Zárate (S 34°06′, W 59°00′)	December 2014	60	18.2[d]	1236.4[d]	Riverine vegetation of public use	1
8 – Buenos Aires – Isla Martín García (S 34°10′, W 58°15′)	February 2014 December 2014 December 2016	120	18.1	967.6	Riverine forest, in Province Reserve	2
9 – Ciudad Autónoma de Buenos Aires (S 34°35′, W 58°28′)	February 2014 December 2014 December 2016	100	18.2	1236.4	Cultivated in botanical garden	1
Stigmaphyllon jatrophifolium						
1 – Misiones – Iguazú (S 25°40′, W 54°27′)	December 2014 December 2015	120	21.7	1950.5	Rain forest, in National Reserve	9
10 – Misiones – Cerro Corá (S 27°30′, W 55°35′)	December 2014	30	22.2[a]	1867.5[a]	Forest fragment of public use	4
11 – Misiones – Apóstoles (S 27°54′, W 55°43′)	December 2013	50	21.0[e]	1882.5[e]	Forest fragment of public use	4
4 – Corrientes – Yapeyú (S 29°28′, W 56°49′)	December 2013 December 2014 January 2017	110	20.2[b]	1555.1[b]	Riverine forest, in public park	5
5 – Entre Ríos – Concordia (S 31°22′, W 57°59′)	December 2014 January 2017	80	19.1	1371.6	Riverine forest, in public park	3
12 – Entre Ríos – Colón (S 32°12′, W 58°12′)	February 2015 January 2017	70	18.1[f]	1067.6[f]	Riverine forest, in public park	3

Notes: Climate data were obtained from National Meteorological Service of Argentina. Climatic data corresponded to the locality studied, except when otherwise indicated by letters: [a]Posadas. [b]Paso de los Libres. [c]Gualeguaychú. [d]Ciudad Autónoma de Buenos Aires. [e]Oberá. [f]Concepción del Uruguay.

we calculated the visitation rates by site for both species of *Stigmaphyllon*. Species that were observed to make contact with reproductive structures while foraging were recorded as legitimate pollinators (i.e., discriminating pollinators from floral visitors).

Centris and *Epicharis* bees are medium-sized to very large and robust (Michener 2007). The bee species captured were assigned to size groups depending on their intertegular spans (Cane 1987; medium: intertegular spans <4 mm; large: 4–6 mm; and very large: >6 mm). Measurements (n = 1–5 individuals per species) were taken using a micrometre to the nearest 0.1 mm, under a stereomicroscope in the laboratory. For each site, we calculated the average pollinator size (APS) as APS = $(\Sigma \text{ITS}_i \times \text{number of visits}_i)$/total number of visits, where ITS is intertegular spans and i is each pollinator species. The richness of oil-collecting bees, flower visitation rates to both *Stigmaphyllon* species and APS were compared among populations.

The collected bees were deposited in the Entomological Collection of the General Botany Unit, Facultad de Agronomía, Universidad de Buenos Aires, Argentina and the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia".

Statistical analyses

To analyse the relationship between the total area of elaiophores per flower along the latitudinal gradient (nine populations across more than 1000 km for *S. bonariense* and six populations across more than 700 km for *S. jatrophifolium*), a multiple ordinary least square regression technique was applied, considering latitude, floral size and species (*S. bonariense* and *S. jatrophifolium*) as predictor variables. Across the sites studied, mean annual temperature and mean annual precipitation were both strongly and inversely associated with latitude (r = −0.96 and −0.93, respectively); therefore, we used latitude as the predictor variable. Species was included in the regression model as a dummy variable (*S. bonariense* = 0 and *S. jatrophifolium* = 1). The best explanatory model was chosen using both R^2adj and Akaike's information criteria (Akaike 1981). Predictor variables were checked for collinearity and residuals of the chosen model for normality and homoscedasticity. The regression analysis was carried out using the average total area of flower elaiophores in each population (identical results were obtained with the individual data – not shown). All the analyses were carried out with InfoStat (Di Rienzo et al. 2010).

To explore associations between the total area of floral elaiophores and biotic variables along the latitudinal gradient, we analysed the linear correlations between floral size, pollinator richness, visitation rate and APS using Pearson's correlation.

Allometry

We examined the relative size relationships of total elaiophore area per flower and floral size using allometric analyses. All size data were log-transformed, and linear regressions for each species carried out; the slopes of these regressions are unaffected by the units of measurement of different structures (Smith 1980) and are commonly used in these analyses (Niklas 1994; Ushimaru and Nakata 2001). Slopes less than 1 represent an allometric relationship in which y (total elaiophore area per flower) increases more slowly than x (floral size), and y/x declines as x increases (Fairbairn 1997) among populations.

Results

Variations in elaiophore size along the latitudinal gradient

Floral elaiophore area decreased with latitude towards the south for both *S. bonariense* and *S. jatrophifolium*) (Table 3; Figure 3; Table A1). At the same time, floral elaiophore area decreased with flower size in *S. jatrophifolium*, but not in *S. bonariense* (Table 3; Figure 4; Table A1). In addition, floral elaiophore area increased with pollinator richness and APS in *S. bonariense* (Table 3) but not in *S. jatrophifolium*. In turn, the flower size decreased towards higher latitude in *S. jatrophifolium* (Table 3), but not in *S. bonariense* (Table 3).

Allometry

The slopes of allometric regression lines were different for both species of *Stigmaphyllon* (Figure 5). The slope for *S. bonariense* was 0.63 (P < 0.0001) and the slope for *S. jatrophifolium* was 1.19 (P < 0.0001).

Assemblages of potential pollinators

In total, we recorded 24 h (16 h in flowers of *S. bonariense* and 8 h in *S. jatrophifolium*) of pollinator observation in the populations studied. The different populations of the two species of *Stigmaphyllon* were visited by 10 species of *Centris* and 2 species of *Epicharis* (legitimate pollinators); additional (non-pollinating) bee species visited the flowers that foraged for floral oil and/or pollen (Table 2). Pollinator richness and APS did not diminish with latitude – except for APS of *S. bonariense* (Table 3). Both species of *Stigmaphyllon* showed low visitation rates and many censuses recorded no visits at all (Table 2; Table A2). Pollinator richness positively correlated with APS and visitation rate in *S. bonariense* (Table 3).

Discussion

We found a marked decrease in the total area of elaiophores per flower towards the southern end of the distribution in both species of *Stigmaphyllon*. Even though there have been species of Malpighiaceae reported without floral elaiophores (Anderson 1979; Cappellari et al. 2011) and/or with intra-individual variations (individuals with flowers of glandular and eglandular morph; Sazima and Sazima 1989), our results confirm for the first time, a reduction in

Table 2. Pollinators and floral visitors.

Population: number – province – locality	Number of censuses (10 min)	Visitation rate		Average pollinator size	Insect captured	
		X ± SD	Range		Pollinators	Floral visitors
Stigmaphyllon bonariense						
1 – Misiones – Iguazú	18	0.0026 ± 0.0027	0–0.0095	5.50	7 *Centris tarsata* (m), 7 *C. trigonoides* (m), 9 *Epicharis* sp. 1 (vl); 5 *Epicharis* sp. 2 (vl)	5 *Tetrapedia* spp. (o)
2 – Misiones – San Ignacio	15	0.0017 ± 0.0016	0–0.0048	4.02	8 *Centris tarsata* (m), 4 *C. trigonoides* (m), 3 *C. varia* (l)	3 *Paratetrapedia nigrispinis* (o), 2 *P. volatilis* (o), 2 *Tetrapedia* spp. (o)
3 – Corrientes – Corrientes	15	0.0028 ± 0.0018	0–0.0063	5.29	1 *Centris burgdorfi* (l), 9 *C. flavifrons* (vl), 1 C. *fuscata* (l), 3 *C. pectoralis* (vl), 2 *C.* cf. *sponsa* (vl), 4 *C. tarsata* (m), 9 *C. trigonoides* (m), 2 *C. varia* (l), 1 *Epicharis* sp. 1 (vl)	2 *Tetrapedia* spp. (o)
4 – Corrientes – Yapeyú	8	0.0029 ± 0.0024	0–0.0060	4.25	1 *Centris pectoralis* (vl), 2 *C. fuscata* (l), 4 *C. trigonoides* (m)	3 *Ceratina* sp. (p), 1 *Tetrapedia* sp. (o)
5 – Entre Ríos – Concordia	9	0.0026 ± 0.0030	0–0.0087	4.35	1 *Centris flavifrons* (vl), 2 *C. fuscata* (l), 1 *C. tarsata* (m), 7 *C. trigonoides* (m)	5 *Tetrapedia* sp. (o)
6 – Entre Ríos – Ibicuy	3	0.0013 ± 0.0011	0–0.0023	4.00	5 *Centris trigonoides* (m)	1 *Xylocopa frontalis* (p)
7 – Buenos Aires – Zárate	6	0.0015 ± 0.0021	0–0.0054	4.00	1 *Centris fuscata* (l), 4 *C. trigonoides* (m)	1 *Bombus pauloensis* (p)
8 – Buenos Aires – Isla Martín García	12	0.0025 ± 0.0022	0–0.0059	4.25	3 *Centris flavifrons* (vl), 5 *C. tarsata* (m), 1 *C. tricolor* (m) 7 *C. trigonoides* (m)	1 *Megachile* sp. (p?), 6 *Paratetrapedia nigrispinis* (o), 2 *Tetrapedia* sp. (o)
9 – Ciudad Autónoma de Buenos Aires	10	0.0014 ± 0.0017	0–0.0040	3.94	1 *Centris fuscata* (l), 7 *C. trigonoides* (m)	2 *Tetrapedia* sp. (o)
Stigmaphyllon jatrophifolium						
1 – Misiones – Iguazú	12	0.0008 ± 0.0015	0–0.0045	3.60	3 *Centris trigonoides* (m)	
10 – Misiones – Cerro Corá	3	s.d.	s.d.	s.d.		
11 – Misiones – Apóstoles	5	0.0039 ± 0.0036	0–0.0071	4.41	2 *Centris bicolor* (l), 2 *C. tarsata* (m)	3 *Tetragonisca fiebrigi* (p), 5 *Trigona spinipes* (p/o)
4 – Corrientes – Yapeyú	11	0.0015 ± 0.0025	0–0.0039	4.62	1 *Centris fuscata* (l), 1 *C. pectoralis* (vl), 4 *C. tarsata* (m)	2 *Ceratina* sp. (p), 1 *Tetrapedia* sp. (o)
5 – Entre Ríos – Concordia	8	0.0035 ± 0.0039	0–0.0091	3.97	3 *Centris tarsata* (m), 2 *C. trigonoides* (m)	1 *Paratetrapedia* sp. (o), 2 *Plebeia* sp. (p), 1 *Tetrapedia* sp. (o)
12 – Entre Ríos – Colón	7	0.0018 ± 0.0025	0–0.0064	3.60	5 *Centris trigonoides* (m)	

Notes: Visitation rates to flowers (mean ± SD and range) and average pollinator size of *Stigmaphyllon bonariense* and *S. jatrophifolium* in the different study sites in Argentina. For floral visitor, the collected resource is indicated; o: floral oil; p: pollen.

Table 3. Relationships between latitude, plant traits, pollinator assemblages and visitation rate in *Stigmaphyllon bonariense* and *S. jatrophifolium*, measured with Pearson correlation coefficient.

	Latitude	Elaiophore	Floral size	Richness	Pollinator size	Visitation rate
Stigmaphyllon bonariense						
Latitude	1	−0.75*	−0.36	−0.55	−0.73	−0.53
Elaiophore		1	0.45	0.82*	0.81*	0.50
Floral size			1	0.50	0.07	0.24
Richness				1	0.74*	0.66*
Pollinator size					1	−0.66
Visitation rate						1
Stigmaphyllon jatrophifolium						
Latitude	1	−0.82*	−0.90*	0.29	−0.14	0.31
Elaiophore		1	0.85*	−0.13	−0.05	−0.01
Floral size			1	−0.38	−0.13	−0.50
Richness				1	0.86	0.27
Pollinator size					1	0.22
Visitation rate						1

Note: $*P \leq 0.05$.

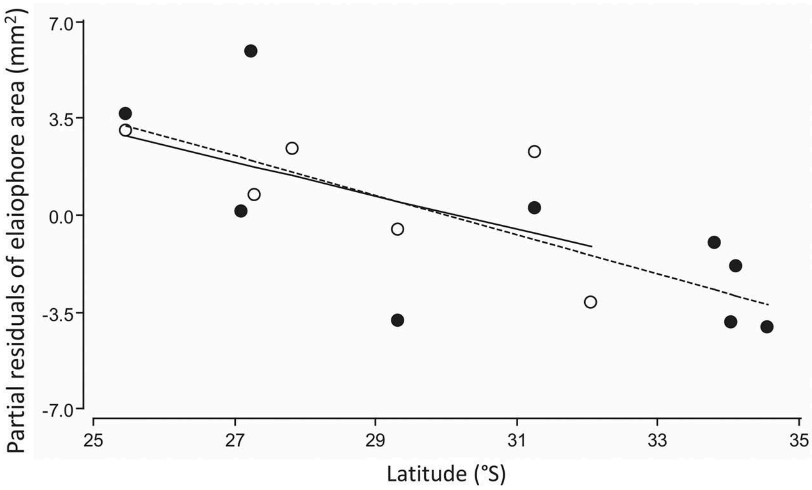

Figure 3. The relationships between elaiophore area and latitude in *Stigmaphyllon bonariense* (filled circles) and in *S. jatrophifolium* (empty circles), while flower size kept constant, are shown with the distribution of the partial residuals of the regression model.

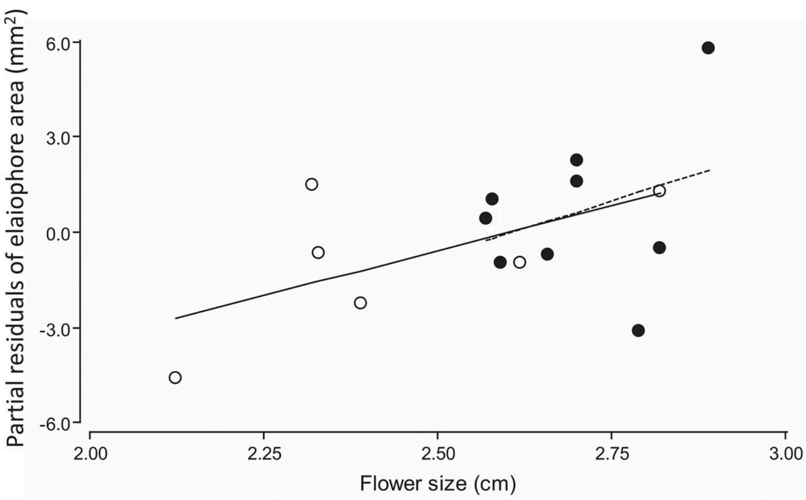

Figure 4. The relationships between elaiophore area and flower size in *Stigmaphyllon bonariense* (filled circles) and in *S. jatrophifolium* (empty circles), while latitude kept constant, are shown with the distribution of the partial residuals of the regression model.

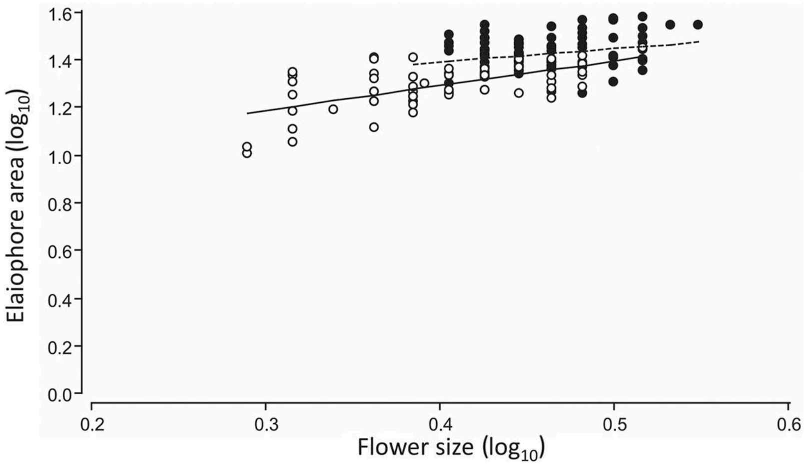

Figure 5. Allometric relationships between log-transformed elaiophore area and log-transformed floral size in *Stigmaphyllon bonariense* (filled circles; $y = 1.15 + 0.63x$; $r^2 = 0.07$; $P = 0.01$; $n = 90$) and *S. jatrophifolium* (empty circles; $y = 0.85 + 1.19x$; $r^2 = 0.37$; $P < 0.0001$; $n = 60$).

the size of these specialised glands in two co-generic species of Malpighiaceae along a wide range of their geographical distributions.

Our results partially support the allometric hypothesis (Prediction a). For *S. bonariense* (a species with a wider distributional range and with more populations included in this study than *S. jatrophifolium*), we observed an allometric reduction (slope of allometric line <1; Figure 5) in elaiophore area with respect to floral size, which did not vary across the studied populations. We also observed that for *S. bonariense* neither the pollinator richness nor the visitation rate decreases; however, we found at the same time a significant decline in the APS with latitude, where flowers have lesser elaiophores. In this species, pollinator size may principally affect the total area of floral elaiophores, due to smaller pollinators needing lower quantities of reward. Regarding the size of pollinators, Cosacov et al. (2014) have reported an inverse pattern by oil-collecting bees of *C. polyrhiza*. This plant species is pollinated by two pollinators: *Centris cineraria* (large-sized bee) in its southernmost localities and *Chalepogenus caeruleus* (small-sized bee) in the northernmost localities, but these oil-collecting bees occur in localities with different climatic and edaphic conditions (Cosacov et al. 2014).

We did, however, observe an isometric reduction in the total area of floral elaiophores in *S. jatrophifolium* (slope of allometric line >1; Figure 5). In this species, it appears that floral size is related to climatic conditions, as has been reported for other species (Olsson and Ågren 2002; Herrera 2005; Cosacov et al. 2012). Herrera (2005) has shown that the flowers of *Rosmarinus officinalis* L. decreased in mass (and corolla size) as the habitat became drier and hotter from mountain to coast. A similar pattern of intraspecific variability was exhibited by *Polemonium viscosum* Nutt. along a gradient of increasing aridity (Galen et al. 1987). Some floral traits involved in plant–pollinator interactions, particularly those related to attraction and floral reward, in general demand large amounts of water and nutrients (Galen 1999). Possibly, this climatic influence could also explain why this species does not reach higher latitudes. Our studied southernmost sites (numbers 6–9 in Figure 2) showed lesser annual mean temperature and precipitation (see Table 1) than other studied sites; moreover, the winter conditions of these sites are colder and with more days with frost (data not shown; National Meteorological Service of Argentina).

The richness of oil-collecting bee species associated with Malpighiaceae decreases markedly from north to south in Argentina (Roig Alsina 2000; Moure et al. 2007; Torretta and Roig Alsina 2016); however, contrary to our expectations (Prediction b), the richness, visitation rates and APS (except for *S. bonariense*) of the captured species of *Centris* and/or *Epicharis* did not exhibit differences across the distribution range studied, in either species of *Stigmaphyllon*.

This fact could be explained by two non-mutually exclusive interpretations: differences in the probability of observing/capturing pollinators and differences in the dependence of oil-collecting bees in Malpighiaceae species among populations. Vegetation types in the northern sites were more complex (e.g., complex structure of vegetation, high species diversity of plants), therefore observing flowering plants in the canopy and capturing bees foraging on these flowers was more difficult and this might have influenced observation/capture rates. It is known that some species of *Centris* show preferences for certain strata in multilayered vegetation (Frankie and Coville 1979) while other bee species do not (Roubik et al. 1982; Roubik 1993). On the other hand, as the species richness of Malpighiaceae decreases from north to south in Argentina, the dependence of oil-collecting bees on Malpighiaceae species among the sampled sites was different. In the northern sites, species of oil-collecting bees can visit a higher number of Malpighiaceae species. Different *Centris* and *Epicharis* species were observed interacting with flowers of the same Malpighiaceae species and the same species of bees were seen collecting floral oil on different species of Malpighiaceae (authors' pers. obs., data not reported, Vogel 1974; Giannini et al. 2013). Thus, the oil-collecting bees exhibit a high dependence on Malpighiaceae species at the populations closer to the southern limits compared to the northern populations, due to the lesser number of oil-rewarding species available for these bees.

Conclusions

This study examined variations in the size of a specialised floral rewarding structure in two sympatric species of *Stigmaphyllon*, and although the total area of floral elaiophores decreased with latitude, we did not find a clear pattern that would apply to both plant species. Possibly, these species of *Stigmaphyllon* have different selection pressures on the variation of their phenotypic traits associated to their pollination. In *S. bonariense*, the pollinator size appears to be related in the total size of the specialised glands while in *S. jatrophifolium* climatic conditions seem to be more strongly related to total elaiophore size.

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Appendix

Table A1. Data for floral size, total area of elaiophores for *Stigmaphyllon bonariense* and *S. jatrophifolium* in studied sites.

	Population			Floral size			Total area elaiophore	
Species	No.	Name	Latitude	(cm)	log	No. of elaiophores	(mm^2)	log
S. bonariense	1	Iguazú	25.68	25	0.398	8	30.89	1.490
S. bonariense	1	Iguazú	25.68	26	0.415	8	29.65	1.472
S. bonariense	1	Iguazú	25.68	28	0.447	8	30.91	1.490
S. bonariense	1	Iguazú	25.68	25	0.398	8	30.84	1.489
S. bonariense	1	Iguazú	25.68	25	0.398	8	32.84	1.516
S. bonariense	1	Iguazú	25.68	2.6	0.415	8	26.10	1.417
S. bonariense	1	Iguazú	25.68	24	0.380	8	2746	1.439
S. bonariense	1	Iguazú	25.68	27	0.431	8	31.19	1.494
S. bonariense	1	Iguazú	25.68	24	0.380	8	31.76	1.502
S. bonariense	1	Iguazú	25.68	27	0.431	8	34.40	1.537
S. bonariense	2	San Ignacio	27.3	3	0.477	8	27.83	1.444
S. bonariense	2	San Ignacio	27.3	2.7	0.431	8	28.46	1.454
S. bonariense	2	San Ignacio	27.3	3.1	0.491	8	27.83	1.444
S. bonariense	2	San Ignacio	27.3	2.7	0.431	8	28.56	1.454
S. bonariense	2	San Ignacio	27.3	2.7	0.431	8	32.56	1.513
S. bonariense	2	San Ignacio	27.3	2.7	0.431	8	23.83	1.358
S. bonariense	2	San Ignacio	27.3	2.9	0.462	8	31.05	1.492
S. bonariense	2	San Ignacio	27.3	2.8	0.447	8	32.56	1.513
S. bonariense	2	San Ignacio	27.3	2.7	0.431	8	22.33	1.358
S. bonariense	2	San Ignacio	27.3	2.9	0.462	8	30.55	1.492
S. bonariense	3	Corrientes	27.42	2.7	0.431	8	24.37	1.387
S. bonariense	3	Corrientes	27.42	2.5	0.398	8	35.05	1.545
S. bonariense	3	Corrientes	27.42	2.8	0.447	8	34.26	1.535
S. bonariense	3	Corrientes	27.42	3	0.477	8	34.03	1.532
S. bonariense	3	Corrientes	27.42	3.1	0.491	8	35.20	1.547
S. bonariense	3	Corrientes	27.42	2.9	0.462	8	37.63	1.576
S. bonariense	3	Corrientes	27.42	3.2	0.505	8	35.12	1.546
S. bonariense	3	Corrientes	27.42	2.9	0.462	8	37.03	1.569
S. bonariense	3	Corrientes	27.42	2.8	0.447	8	36.76	1.565
S. bonariense	3	Corrientes	27.42	3	0.477	8	38.23	1.582
S. bonariense	4	Yapeyú	29.47	2.7	0.431	8	27.08	1.433
S. bonariense	4	Yapeyú	29.47	2.8	0.447	8	29.08	1.464
S. bonariense	4	Yapeyú	29.47	2.7	0.431	8	24.32	1.386
S. bonariense	4	Yapeyú	29.47	2.9	0.462	8	23.60	1.373
S. bonariense	4	Yapeyú	29.47	3	0.477	8	24.98	1.398
S. bonariense	4	Yapeyú	29.47	2.7	0.431	8	22.82	1.358
S. bonariense	4	Yapeyú	29.47	2.8	0.447	8	23.18	1.365
S. bonariense	4	Yapeyú	29.47	2.7	0.431	8	24.48	1.389
S. bonariense	4	Yapeyú	29.47	2.9	0.462	8	20.35	1.309
S. bonariense	4	Yapeyú	29.47	2.7	0.431	8	24.48	1.389
S. bonariense	5	Concordia	31.37	2.5	0.398	8	26.02	1.415
S. bonariense	5	Concordia	31.37	2.6	0.415	8	25.65	1.409
S. bonariense	5	Concordia	31.37	2.5	0.398	8	27.85	1.445
S. bonariense	5	Concordia	31.37	2.6	0.415	8	28.15	1.449
S. bonariense	5	Concordia	31.37	2.7	0.431	8	28.30	1.452
S. bonariense	5	Concordia	31.37	2.5	0.398	8	23.48	1.371
S. bonariense	5	Concordia	31.37	2.6	0.415	8	30.41	1.483
S. bonariense	5	Concordia	31.37	2.8	0.447	8	28.33	1.452
S. bonariense	5	Concordia	31.37	2.5	0.398	8	29.57	1.471
S. bonariense	5	Concordia	31.37	2.5	0.398	8	24.46	1.389
S. bonariense	6	Ibicuy	33.85	2.4	0.380	8	29.50	1.470
S. bonariense	6	Ibicuy	33.85	2.9	0.462	8	25.88	1.413
S. bonariense	6	Ibicuy	33.85	2.7	0.431	8	23.70	1.375
S. bonariense	6	Ibicuy	33.85	2.5	0.398	8	26.51	1.423
S. bonariense	6	Ibicuy	33.85	2.6	0.415	8	25.08	1.399
S. bonariense	6	Ibicuy	33.85	2.6	0.415	8	28.83	1.460
S. bonariense	6	Ibicuy	33.85	3	0.477	8	27.54	1.440
S. bonariense	6	Ibicuy	33.85	3	0.477	8	29.58	1.471

(*Continued*)

Table A1. (*Continued*).

Species	Population		Latitude	Floral size		No. of elaiophores	Total area elaiophore	
	No.	Name		(cm)	log		(mm^2)	log
S. bonariense	6	Ibicuy	33.85	2.7	0.431	8	23.66	1.374
S. bonariense	6	Ibicuy	33.85	2.6	0.415	8	26.98	1.431
S. bonariense	7	Zárate	34.08	2.5	0.398	8	27.49	1.439
S. bonariense	7	Zárate	34.08	2.6	0.415	8	24.36	1.387
S. bonariense	7	Zárate	34.08	2.4	0.380	8	20.04	1.302
S. bonariense	7	Zárate	34.08	2.8	0.447	8	24.61	1.391
S. bonariense	7	Zárate	34.08	2.6	0.415	8	22.65	1.355
S. bonariense	7	Zárate	34.08	2.6	0.415	8	23.27	1.367
S. bonariense	7	Zárate	34.08	2.8	0.447	8	24.23	1.384
S. bonariense	7	Zárate	34.08	2.8	0.447	8	24.55	1.390
S. bonariense	7	Zárate	34.08	2.5	0.398	8	21.92	1.341
S. bonariense	7	Zárate	34.08	3	0.477	8	22.72	1.356
S. bonariense	8	M. García	34.16	2.4	0.380	6	28.73	1.458
S. bonariense	8	M. García	34.16	2.9	0.462	8	25.80	1.412
S. bonariense	8	M. García	34.16	2.7	0.431	8	25.00	1.398
S. bonariense	8	M. García	34.16	2.5	0.398	8	27.57	1.440
S. bonariense	8	M. García	34.16	2.6	0.415	8	24.68	1.392
S. bonariense	8	M. García	34.16	2.6	0.415	8	26.52	1.424
S. bonariense	8	M. García	34.16	3	0.477	8	25.30	1.403
S. bonariense	8	M. García	34.16	3	0.477	8	31.54	1.499
S. bonariense	8	M. García	34.16	2.7	0.431	6	18.44	1.266
S. bonariense	8	M. García	34.16	2.6	0.415	8	24.91	1.396
S. bonariense	9	C.A.B.A.	34.58	2.5	0.398	8	27.90	1.446
S. bonariense	9	C.A.B.A.	34.58	2.5	0.398	8	26.64	1.426
S. bonariense	9	C.A.B.A.	34.58	2.8	0.447	8	25.95	1.414
S. bonariense	9	C.A.B.A.	34.58	2.4	0.380	10	21.60	1.334
S. bonariense	9	C.A.B.A.	34.58	2.8	0.447	9	18.17	1.259
S. bonariense	9	C.A.B.A.	34.58	2.8	0.447	8	25.88	1.413
S. bonariense	9	C.A.B.A.	34.58	2.6	0.415	8	21.93	1.341
S. bonariense	9	C.A.B.A.	34.58	2.5	0.398	8	21.42	1.331
S. bonariense	9	CABA	34.58	2.3	0.362	8	16.83	1.226
S. bonariense	9	C.A.B.A.	34.58	2.7	0.431	9	23.66	1.374
S. jatrophifolium	1	Iguazú	25.68	3	0.477	8	28.37	1.453
S. jatrophifolium	1	Iguazú	25.68	2.8	0.447	8	24.11	1.382
S. jatrophifolium	1	Iguazú	25.68	2.8	0.447	8	22.38	1.350
S. jatrophifolium	1	Iguazú	25.68	2.8	0.447	8	26.15	1.417
S. jatrophifolium	1	Iguazú	25.68	2.7	0.431	8	25.29	1.403
S. jatrophifolium	1	Iguazú	25.68	2.8	0.447	8	24.11	1.382
S. jatrophifolium	1	Iguazú	25.68	2.8	0.447	8	26.15	1.417
S. jatrophifolium	1	Iguazú	25.68	2.7	0.431	8	25.29	1.403
S. jatrophifolium	1	Iguazú	25.68	2.8	0.447	8	22.38	1.350
S. jatrophifolium	1	Iguazú	25.68	3	0.477	8	28.37	1.453
S. jatrophifolium	10	Cerro Corá	27.48	2.5	0.398	8	23.19	1.365
S. jatrophifolium	10	Cerro Corá	27.48	2.6	0.415	8	23.85	1.377
S. jatrophifolium	10	Cerro Corá	27.48	2.7	0.431	8	25.41	1.405
S. jatrophifolium	10	Cerro Corá	27.48	2.8	0.447	8	19.36	1.287
S. jatrophifolium	10	Cerro Corá	27.48	2.5	0.398	8	18.71	1.272
S. jatrophifolium	10	Cerro Corá	27.48	2.6	0.415	8	18.08	1.257
S. jatrophifolium	10	Cerro Corá	27.48	2.5	0.398	8	23.16	1.365
S. jatrophifolium	10	Cerro Corá	27.48	2.7	0.431	8	20.15	1.304
S. jatrophifolium	10	Cerro Corá	27.48	2.6	0.415	8	25.17	1.401
S. jatrophifolium	10	Cerro Corá	27.48	2.7	0.431	8	20.33	1.308
S. jatrophifolium	11	Apóstoles	28	2.5	0.398	8	22.06	1.344
S. jatrophifolium	11	Apóstoles	28	2.2	0.342	8	21.72	1.337
S. jatrophifolium	11	Apóstoles	28	2.4	0.380	8	21.92	1.341
S. jatrophifolium	11	Apóstoles	28	2	0.301	8	21.71	1.337
S. jatrophifolium	11	Apóstoles	28	2.5	0.398	8	21.13	1.325
S. jatrophifolium	11	Apóstoles	28	2.5	0.398	8	21.25	1.327
S. jatrophifolium	11	Apóstoles	28	2.5	0.398	7	23.24	1.366
S. jatrophifolium	11	Apóstoles	28	2.5	0.398	8	22.94	1.361
S. jatrophifolium	11	Apóstoles	28	2.2	0.342	8	18.55	1.268

(*Continued*)

Table A1. (*Continued*).

Species	Population		Latitude	Floral size		No. of elaiophores	Total area elaiophore	
	No.	Name		(cm)	log		(mm^2)	log
S. jatrophifolium	11	Apóstoles	28	2	0.301	8	22.21	1.347
S. jatrophifolium	4	Yapeyú	29.47	2.2	0.342	7	18.32	1.263
S. jatrophifolium	4	Yapeyú	29.47	2.3	0.362	8	18.31	1.263
S. jatrophifolium	4	Yapeyú	29.47	2.8	0.447	8	21.45	1.331
S. jatrophifolium	4	Yapeyú	29.47	2.5	0.398	8	21.26	1.328
S. jatrophifolium	4	Yapeyú	29.47	2.4	0.380	7	18.19	1.260
S. jatrophifolium	4	Yapeyú	29.47	2.5	0.398	8	21.60	1.334
S. jatrophifolium	4	Yapeyú	29.47	2.3	0.362	8	16.32	1.213
S. jatrophifolium	4	Yapeyú	29.47	2.3	0.362	8	21.21	1.327
S. jatrophifolium	4	Yapeyú	29.47	2.3	0.362	8	19.40	1.288
S. jatrophifolium	4	Yapeyú	29.47	2.4	0.380	8	17.76	1.250
S. jatrophifolium	5	Concordia	31.37	2.4	0.380	8	21.38	1.330
S. jatrophifolium	5	Concordia	31.37	2.3	0.362	8	25.46	1.406
S. jatrophifolium	5	Concordia	31.37	2.2	0.342	8	25.66	1.409
S. jatrophifolium	5	Concordia	31.37	2.2	0.342	8	20.95	1.321
S. jatrophifolium	5	Concordia	31.37	2.4	0.380	8	22.81	1.358
S. jatrophifolium	5	Concordia	31.37	2.2	0.342	8	25.03	1.399
S. jatrophifolium	5	Concordia	31.37	2.3	0.362	8	15.10	1.179
S. jatrophifolium	5	Concordia	31.37	2	0.301	8	15.26	1.183
S. jatrophifolium	5	Concordia	31.37	2.7	0.431	8	21.65	1.336
S. jatrophifolium	5	Concordia	31.37	2.5	0.398	8	21.61	1.335
S. jatrophifolium	12	Colón	32.13	2.2	0.342	8	16.73	1.223
S. jatrophifolium	12	Colón	32.13	2.2	0.342	8	13.12	1.118
S. jatrophifolium	12	Colón	32.13	1.9	0.279	8	10.06	1.003
S. jatrophifolium	12	Colón	32.13	2.4	0.380	8	18.70	1.272
S. jatrophifolium	12	Colón	32.13	2.3	0.362	8	17.53	1.244
S. jatrophifolium	12	Colón	32.13	2	0.301	8	17.72	1.249
S. jatrophifolium	12	Colón	32.13	2	0.301	8	11.23	1.050
S. jatrophifolium	12	Colón	32.13	1.9	0.279	8	10.72	1.030
S. jatrophifolium	12	Colón	32.13	2	0.301	8	12.78	1.107
S. jatrophifolium	12	Colón	32.13	2.1	0.322	8	19.84	1.298

Note: Population numbers correspond to those in Table 1.

Table A2. Data about visitation rate for *Stigmaphyllon bonariense* and *S. jatrophifolium* in studied sites.

Species	Population		Date	Observed flowers	Observed time	No. of legitimate visit	Visitation rate
	No.	Name					
S. bonariense	1	Iguazú	28 November 2015	21	10	2	0.0095
S. bonariense	1	Iguazú	28 November 2015	17	10	0	0.0000
S. bonariense	1	Iguazú	28 November 2015	19	10	1	0.0053
S. bonariense	1	Iguazú	29 November 2015	125	10	1	0.0008
S. bonariense	1	Iguazú	29 November 2015	78	10	1	0.0008
S. bonariense	1	Iguazú	29 November 2015	58	10	0	0.0000
S. bonariense	1	Iguazú	03 December 2014	71	10	2	0.0028
S. bonariense	1	Iguazú	03 December 2014	29	10	2	0.0069
S. bonariense	1	Iguazú	04 December 2014	56	10	0	0.0000
S. bonariense	1	Iguazú	04 December 2014	34	10	1	0.0029
S. bonariense	1	Iguazú	04 December 2014	59	10	3	0.0051
S. bonariense	1	Iguazú	05 December 2014	122	10	1	0.0008
S. bonariense	1	Iguazú	03 March 2017	132	10	4	0.0030
S. bonariense	1	Iguazú	03 March 2017	119	10	5	0.0042
S. bonariense	1	Iguazú	03 March 2017	119	10	3	0.0025
S. bonariense	1	Iguazú	03 March 2017	119	10	2	0.0017
S. bonariense	1	Iguazú	03 March 2017	145	10	0	0.0000
S. bonariense	1	Iguazú	03 March 2017	122	10	0	0.0000
S. bonariense	2	San Ignacio	02 December 2014	44	10	1	0.0023
S. bonariense	2	San Ignacio	02 December 2014	21	10	1	0.0048
S. bonariense	2	San Ignacio	06 December 2014	88	10	3	0.0034
S. bonariense	2	San Ignacio	02 December 2014	54	10	2	0.0037
S. bonariense	2	San Ignacio	02 December 2014	38	10	1	0.0026
S. bonariense	2	San Ignacio	02 December 2014	79	10	1	0.0013
S. bonariense	2	San Ignacio	08 December 2015	34	10	0	0.0000
S. bonariense	2	San Ignacio	08 December 2015	55	10	0	0.0000
S. bonariense	2	San Ignacio	08 December 2015	44	10	1	0.0023
S. bonariense	2	San Ignacio	08 December 2015	59	10	2	0.0034
S. bonariense	2	San Ignacio	09 December 2015	111	10	3	0.0027
S. bonariense	2	San Ignacio	09 December 2015	91	10	0	0.0000
S. bonariense	2	San Ignacio	26 January 2017	25	10	0	0.0000
S. bonariense	2	San Ignacio	26 January 2017	35	10	0	0.0000
S. bonariense	2	San Ignacio	26 January 2017	40	10	0	0.0000
S. bonariense	3	Corrientes	15 December 2015	73	10	3	0.0041
S. bonariense	3	Corrientes	15 December 2015	61	10	2	0.0033
S. bonariense	3	Corrientes	15 December 2015	31	10	1	0.0032
S. bonariense	3	Corrientes	15 December 2015	45	10	1	0.0022
S. bonariense	3	Corrientes	16 December 2015	65	10	3	0.0046
S. bonariense	3	Corrientes	16 December 2015	48	10	3	0.0063
S. bonariense	3	Corrientes	16 December 2015	24	10	0	0.0000
S. bonariense	3	Corrientes	17 December 2015	62	10	2	0.0032
S. bonariense	3	Corrientes	17 December 2015	39	10	0	0.0000
S. bonariense	3	Corrientes	05 February 2017	68	10	2	0.0029
S. bonariense	3	Corrientes	05 February 2017	92	10	4	0.0043
S. bonariense	3	Corrientes	08 April 2017	145	10	4	0.0028
S. bonariense	3	Corrientes	08 April 2017	184	10	3	0.0016
S. bonariense	3	Corrientes	08 April 2017	97	10	4	0.0041
S. bonariense	3	Corrientes	08 April 2017	74	10	0	0.0000
S. bonariense	4	Yapeyú	03 December 2013	17	10	1	0.0059
S. bonariense	4	Yapeyú	03 December 2013	25	10	1	0.0040
S. bonariense	4	Yapeyú	03 December 2013	47	10	1	0.0021
S. bonariense	4	Yapeyú	26 December 2013	67	10	1	0.0015
S. bonariense	4	Yapeyú	30 November 2014	41	10	0	0.0000
S. bonariense	4	Yapeyú	01 December 2014	28	10	1	0.0036
S. bonariense	4	Yapeyú	01 December 2014	33	10	2	0.0061
S. bonariense	4	Yapeyú	30 November 2014	41	10	0	0.0000
S. bonariense	5	Concordia	03 December 2014	23	10	2	0.0087
S. bonariense	5	Concordia	04 December 2014	84	10	3	0.0036
S. bonariense	5	Concordia	04 December 2014	67	10	2	0.0030
S. bonariense	5	Concordia	04 December 2014	53	10	0	0.0000
S. bonariense	5	Concordia	05 December 2014	52	10	3	0.0058

(*Continued*)

Table A2. (*Continued*).

Species	Population		Date	Observed flowers	Observed time	No. of legitimate visit	Visitation rate
	No.	Name					
S. bonariense	5	Concordia	05 December 2014	65	10	0	0.0000
S. bonariense	5	Concordia	19 January 2017	52	10	0	0.0000
S. bonariense	5	Concordia	19 January 2017	35	10	0	0.0000
S. bonariense	5	Concordia	19 January 2017	48	10	1	0.0021
S. bonariense	6	Ibicuy	09 December 2012	25	10	0	0.0000
S. bonariense	6	Ibicuy	09 December 2012	124	10	2	0.0016
S. bonariense	6	Ibicuy	21 December 2013	131	10	3	0.0023
S. bonariense	7	Zárate	10 December 2014	55	10	3	0.0055
S. bonariense	7	Zárate	10 December 2014	41	10	1	0.0024
S. bonariense	7	Zárate	10 December 2014	38	10	0	0.0000
S. bonariense	7	Zárate	11 December 2014	29	10	0	0.0000
S. bonariense	7	Zárate	11 December 2014	71	10	1	0.0014
S. bonariense	7	Zárate	11 December 2014	53	10	0	0.0000
S. bonariense	8	M. García	14 February 2014	41	10	2	0.0049
S. bonariense	8	M. García	14 February 2014	19	10	0	0.0000
S. bonariense	8	M. García	14 February 2014	77	10	3	0.0039
S. bonariense	8	M. García	14 February 2014	81	10	4	0.0049
S. bonariense	8	M. García	27 February 2014	44	10	0	0.0000
S. bonariense	8	M. García	27 February 2014	49	10	1	0.0020
S. bonariense	8	M. García	16 December 2014	34	10	2	0.0059
S. bonariense	8	M. García	16 December 2014	21	10	0	0.0000
S. bonariense	8	M. García	17 December 2014	51	10	1	0.0020
S. bonariense	8	M. García	17 December 2014	33	10	1	0.0030
S. bonariense	8	M. García	28 December 2016	51	10	2	0.0039
S. bonariense	8	M. García	28 December 2016	23	10	0	0.0000
S. bonariense	9	Caba	12 February 2014	58	10	2	0.0034
S. bonariense	9	Caba	12 February 2014	124	10	0	0.0000
S. bonariense	9	Caba	15 February 2014	78	10	1	0.0013
S. bonariense	9	Caba	15 February 2014	69	10	0	0.0000
S. bonariense	9	Caba	28 December 2014	75	10	3	0.0040
S. bonariense	9	Caba	29 December 2014	48	10	1	0.0021
S. bonariense	9	Caba	29 December 2014	55	10	0	0.0000
S. bonariense	9	Caba	30 December 2014	29	10	1	0.0034
S. bonariense	9	Caba	18 December 2016	19	10	0	0.0000
S. bonariense	9	Caba	20 December 2016	29	10	0	0.0000
S. jatrophifolium	1	Iguazú	04 December 2014	25	10	0	0.0000
S. jatrophifolium	1	Iguazú	04 December 2014	31	10	0	0.0000
S. jatrophifolium	1	Iguazú	04 December 2014	36	10	0	0.0000
S. jatrophifolium	1	Iguazú	05 December 2014	44	10	1	0.0023
S. jatrophifolium	1	Iguazú	05 December 2014	28	10	0	0.0000
S. jatrophifolium	1	Iguazú	05 December 2014	17	10	0	0.0000
S. jatrophifolium	1	Iguazú	30 November 2015	22	10	0	0.0000
S. jatrophifolium	1	Iguazú	30 November 2015	25	10	0	0.0000
S. jatrophifolium	1	Iguazú	30 November 2015	44	10	1	0.0023
S. jatrophifolium	1	Iguazú	01 December 2015	22	10	1	0.0045
S. jatrophifolium	1	Iguazú	01 December 2015	19	10	0	0.0000
S. jatrophifolium	1	Iguazú	01 December 2015	34	10	0	0.0000
S. jatrophifolium	10	Cerro Corá	04 December 2014	22	10	0	0.0000
S. jatrophifolium	10	Cerro Corá	04 December 2014	19	10	0	0.0000
S. jatrophifolium	10	Cerro Corá	04 December 2014	31	10	0	0.0000
S. jatrophifolium	11	Apóstoles	08 December 2013	18	10	1	0.0056
S. jatrophifolium	11	Apóstoles	08 December 2013	14	10	1	0.0071
S. jatrophifolium	11	Apóstoles	09 December 2013	29	10	2	0.0069
S. jatrophifolium	11	Apóstoles	09 December 2013	38	10	0	0.0000
S. jatrophifolium	11	Apóstoles	09 December 2013	31	10	0	0.0000
S. jatrophifolium	4	Yapeyú	03 December 2012	92	30	1	0.0004
S. jatrophifolium	4	Yapeyú	03 December 2012	105	10	1	0.0010
S. jatrophifolium	4	Yapeyú	26 February 2013	117	10	1	0.0009
S. jatrophifolium	4	Yapeyú	26 February 2013	25	10	0	0.0000
S. jatrophifolium	4	Yapeyú	20 December 2013	18	10	0	0.0000
S. jatrophifolium	4	Yapeyú	30 November 2014	51	10	2	0.0039

(*Continued*)

Table A2. (*Continued*).

Species	Population No.	Population Name	Date	Observed flowers	Observed time	No. of legitimate visit	Visitation rate
S. jatrophifolium	4	Yapeyú	01 December 2014	29	10	0	0.0000
S. jatrophifolium	4	Yapeyú	01 December 2014	44	10	1	0.0023
S. jatrophifolium	4	Yapeyú	01 December 2014	45	10	0	0.0000
S. jatrophifolium	4	Yapeyú	25 January 2017	12	10	1	0.0083
S. jatrophifolium	4	Yapeyú	25 January 2017	17	10	0	0.0000
S. jatrophifolium	5	Concordia	03 December 2014	46	10	2	0.0043
S. jatrophifolium	5	Concordia	04 December 2014	38	10	3	0.0079
S. jatrophifolium	5	Concordia	04 December 2014	22	10	2	0.0091
S. jatrophifolium	5	Concordia	04 December 2014	47	10	3	0.0064
S. jatrophifolium	5	Concordia	04 December 2014	36	10	0	0.0000
S. jatrophifolium	5	Concordia	04 December 2014	36	10	0	0.0000
S. jatrophifolium	5	Concordia	25 January 2017	45	10	0	0.0000
S. jatrophifolium	5	Concordia	25 January 2017	45	10	0	0.0000
S. jatrophifolium	12	Colón	15 February 2015	47	10	3	0.0064
S. jatrophifolium	12	Colón	15 February 2015	26	10	1	0.0038
S. jatrophifolium	12	Colón	16 December 2015	28	10	0	0.0000
S. jatrophifolium	12	Colón	16 December 2015	40	10	0	0.0000
S. jatrophifolium	12	Colón	16 December 2015	38	10	1	0.0026
S. jatrophifolium	12	Colón	25 January 2017	25	10	0	0.0000

Note: Population numbers correspond to those in Table 1.