

# Draft information

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## Requests to co-authors

- Title suggestions/feedback?
- Feedback primarily on abstract, introduction and discussion prior to submission.

## Changes since the last draft

- Adjusted language away from competition for pollination towards pollination service and pollen deposition across the paper.
- Removed the section where we calculated competition/facilitation in ecological communities
- Other minor adjustments to address comments by reviews received when submitted to Proceedings B
- Rewrote abstract
- Updated title

## To-do

- Update supplementary information

# The trade-offs of ~~pollinator~~ sharing: pollination service is determined by the community context

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What  
about the  
writing?

Cut?

## Abstract

whose  
abundance,  
visitation,  
and traits?

Why does this lack of a space  
keep happening?

[ 16 A fundamental feature of pollination systems is the indirect facilitation and competition that  
17 arises when plants species share pollinators. When plants share pollinators, the pollination  
18 service can be influenced, ~~not only by~~ <sup>this depends not only on</sup> how many partners plant species share, but also by  
19 multiple intertwined factors like abundance, visitation, or traits. These factors inherently  
20 operate at the community level. However, most of our understanding of how these factors  
21 may affect the pollination service is based on systems of up to a handful of species. By  
22 examining comprehensive empirical data in eleven natural communities, here we show that  
23 the pollination service is—surprisingly—only partially influenced by the number of shared  
24 pollinators. <sup>Instead,</sup> ~~The~~ factors that most influence the pollination service (abundance and visit  
25 effectiveness) also introduce a trade-off between the absolute amount of conspecific pollen  
26 received and the amount relative to heterospecific pollen. Importantly, the ways plants appear  
27 to balance these trade-offs depend strongly on the community context, as most species showed  
28 flexibility in the strategy they used to cope with competition for pollination.

29 **Keywords:** interspecific pollen transfer, pollen deposition, pollination costs and benefits,  
30 pollination network, pollination niche, and pollinator sharing

## 31 Introduction

32 Animal pollination plays a disproportionately important role in food production and maintenance of global biodiversity (Klein et al. 2007, Bascompte and Jordano 2007, Ollerton et al. 33 2011). At a pairwise level, the mutually beneficial relationship between plants and pollinators 34 underpins the pollination service. At a community level, sometimes involving hundreds of 35 species, both plant and pollinator species are connected in a myriad of indirect connections 36 when pollination partners are shared. These indirect connections can dramatically alter the 37 quality of the pollination service that plants receive because they determine how conspecific 38 and heterospecific pollen is transferred across the community (Morales and Traveset 2008). 39 Generally speaking, there is a trade-off between the benefits gained from <sup>a species</sup> maximising ~~the~~ <sup>its</sup> 40 number of partners and the costs of sharing them with other plant species (Waser 1978). 41 However, due to the large number of factors that operate at the community level, we <sup>generally</sup> ~~do~~ 42 not <sup>know</sup> ~~understand~~ how sharing pollinators affects the pollination service beyond systems with 43 more than a handful of species. Here we investigate how pollinator sharing affects pollen 44 transfer *in natural communities* and how it compares to other factors known to play a role in 45 community dynamics like abundance, traits, and visitation patterns. 46

47 There are two main mechanisms through which sharing pollinators can affect plant fertilisation (Morales and Traveset 2008). The first is by changes in intraspecific pollen transfer. 48 <sup>Intra?</sup> 49 Interspecific pollen transfer happens, for example, when plants with more attractive flowers 50 might reduce the number of visits to those <sup>less of</sup> ~~less of~~ attractive neighbouring plants, and hence 51 reduce the amount of *conspecific pollen* deposited by animals (Yang et al. 2011). The second 52 is via interspecific pollen transfer. In that case, even receiving a visit might not necessarily 53 translate into fertilisation (Campbell and Motten 1985) because a focal plant might receive 54 *heterospecific pollen* or because pollen from the focal plant might be lost to different species. 55 Naturally, the precise effects on female or male plant fitness of conspecific and heterospecific 56 pollen deposition depend on the species involved <sup>(re-ts)</sup> and are unknown for many plant species.

TP  
hmm  
57 However, even for species well adapted to pollinator sharing, receiving foreign pollen on  
58 stigmas or losing pollen to foreign stigmas, is neutral (at best). Indeed, there is substantial  
59 evidence supporting the idea that heterospecific pollen deposition can be detrimental to seed  
60 production and plant fitness (Ashman and Arceo-Gómez 2013, Arceo-Gómez and Ashman  
61 2016).

else being equal  
62 All together, provided pollen is viable and compatible (de Jong et al. 1992, Dafni and Firmage  
63 2000, Ramsey and Vaughton 2000), the higher the quantity of conspecific pollen and its  
64 purity (relative to heterospecific pollen), the better the pollination service received by the  
65 focal plant. As such, measuring conspecific and heterospecific pollen deposition provides  
66 a good indication of the potential levels of facilitation and competition a plant population  
67 might experience.

68 By definition, intra- and interspecific pollen transfer occur at the community scale. However,  
69 with few exceptions (Aizen and Rovere 2010, Tur et al. 2016), most of what we know about  
70 pollen transfer and its relationship with key ecological factors are based on studies with two  
71 plant species. That is partly ~~no~~ because at the community scale the factors that determine  
72 the patterns of pollen deposition are tightly intertwined, operate simultaneously, and may  
73 lead to emergent phenomena not observed at smaller scales (Flanagan et al. 2011). For  
74 instance, recent empirical evidence suggests that plants with flowering traits that are “original”  
75 relative to others in the community generally have fewer interaction partners (Coux et al.  
76 2016).

77 This evidence aligns with the notion that a species that interacts with few species does so  
78 strongly with each of them whereas a species that interacts with a large number of species  
79 does so comparatively weakly (Bascompte et al. 2006, Vázquez et al. 2007, Thébault and  
80 Fontaine 2008). If evolutionary specialisation occurs by changing traits to focus on fewer but  
81 better partners (Caruso 2000), we should expect a reduction of competition for pollinators in  
82 species with “original” traits and an increase of competition in species with a large number

83 of interaction partners (Gibson et al. 2012, Carnevalheiro et al. 2014). Alternatively, it might  
84 also be the case that abundance (for example, in terms of flower or pollen counts) is the  
85 dominant force driving pollen transfer (Seifan et al. 2014). Abundant plant species might  
86 experience a dilution of available pollinators (Feinsinger 1987, Feldman et al. 2004) but might  
87 also receive more effective visits by capitalising on a larger share of both visits and the pollen  
88 carried by pollinators (???). In this case, a potential reduction in the absolute amount of  
89 conspecific pollen received could be compensated by an increase in the amount of conspecific  
90 pollen relative to heterospecific pollen. Altogether, it is clear that these ecological factors can  
91 indeed shape pollen deposition at the community level. However, we still do not understand  
92 their relative importance and the trade-offs that might exist between them.

why bold?

93 Here, we investigate pollen deposition dynamics at the community scale using empirical data  
94 from eleven plant-pollinator communities in the Argentinian Pampas. First, we investigate the  
95 relative contribution that four ecological factors ~~have~~ <sup>make</sup> to the pollination service. Specifically,  
96 we hypothesise that there are trade-offs on how these factors affect the quantity and purity of  
97 conspecific pollen deposition. While quantity and purity should decrease for plants that share  
98 many pollination partners, other factors like the plant's functional originality, its relative  
99 floral abundance, and its visitation patterns should have the potential to compensate for  
100 this decrease. Second, we examine how these four factors that might affect pollen deposition  
101 can change across communities where species are present. Because these factors may affect  
102 the pollination service in contrasting ways, and a species role is relative to other species in  
103 the community, we predict that species present in multiple communities should be flexible  
104 enough to ~~to~~ compete for pollinators under different community contexts.

successfully?

## 105 Methods

106 We collected data from eleven co-flowering plant communities and their pollinators in three  
107 locations in the Argentinian Pampas. In each location, we sampled two restored and two  
108 agricultural fragments, except in one located in the Flooding Pampas, where we were only  
109 able to sample one restored fragment due to the lack of available sites.

### 110 Factors affecting quantity and purity of pollination service

111 Our first objective was to investigate the relative contribution that different ecological factors  
112 have on pollen deposition. Generally speaking, we expect that any factor that increases the  
113 amount of conspecific pollen deposited in stigmas, both in quantity and purity relative to  
114 heterospecific pollen, also has a positive effect on the pollination service. Specifically, we  
115 investigated the effect of (i) a plant's number of shared pollinator species, (ii) a plant's  
116 abundance relative to the rest of the community, (iii) <sup>a plant's</sup> ~~the~~ mean visit potential—a metric that  
117 combines the amount and type of pollen carried by floral visitors and the number of visits it  
118 receives from them, and (iv) the plant's functional originality (Laliberté and Legendre 2010).  
119 See *Data Analysis* section below for more details on these four factors.

### 120 Data collection

121 In each of the studied communities, we quantified pollen deposition in a subset of plant  
122 species between December 2010 and February 2011. This subset comprised between three  
123 and nine common insect-pollinated (entomophilous) plant species that were flowering during  
124 the sampling period. Based on data from previous years (Marrero et al. 2014), we chose plant  
125 species such that they cover a wide range on a specialization-generalization gradient as well  
126 as a wide range of abundances. In each of the selected plants, we removed all flowers leaving  
127 only buds that were expected to go into florescence on the next day. Two days after flowering,

we collected all remaining flowers and counted the number of conspecific and heterospecific pollen grains in their pistils. More details can be found in Marrero et al. (2016).

To obtain the number of shared pollinators for each species, we collected data to construct qualitative and quantitative pollination networks. Qualitative networks were constructed based on ten-hour observations of floral visits in each fragment. Quantitative networks were constructed using two 50 m randomly located transects in each fragment. We counted and collected all floral visitors found in a 2 m wide strip while walking at a pace of 10 m per minute (Memmott 1999, Marrero et al. 2014). We visited the transects each month between November 2010 and March 2011. To obtain floral abundance, we counted all units of floral attraction found during an independent sampling of the same transects used to construct the quantitative visitation networks. To estimate visit potential, we need to construct pollen transfer networks in addition to the visitation networks. To do this, we examined the pollen loads present on the floral visitors collected (Marrero et al. 2017). When the pollen count on an individual animal was estimated to be less than 2,000 grains, we identified every grain to the species level when possible and to pollen complexes when it was not. When the pollen count was above 2,000 grains, we classified approximately 50% of pollen and total pollen counts were extrapolated (Bosch et al. 2009). Finally, we also recorded morphological traits that relate to plant type (herb, shrub, climber), life cycle (annual, perennial), flower colouration, phenology, and whether the species is native in the study region. More details can be found in Marrero *et al.* (2014 and 2017).

## Data analysis

To investigate the impact of ecological factors on pollination services, we used two sets of linear mixed models (LMM) with bootstrap resampling. The response variables for these model sets were the number of conspecific and heterospecific pollen grains deposited per stigma in flowers open to animal-mediated pollination. We used LMMs in which pollen loads



153 were log-transformed because these models offered a better fit than equivalent GLMMs with  
154 Poisson (or quasi-Poisson) error structure. Models were fitted using the R package nlme  
155 3.1-131 (Pinheiro et al. 2018).

156 Because the amount of deposited pollen can vary widely across species, and potentially also  
157 across communities, we evaluated two possible structures for the random effects: one that  
158 includes a random intercept for plant species, and one that treats measures from species across  
159 different communities independently. We selected the best random structure by comparing  
160 the median Akaike Information Criterion for small samples (AICc).

161 As fixed predictors in the models, we included the four ecological factors described above.  
162 Specifically, we calculated the number of shared pollinators for each plant species by pooling  
163 data from the qualitative and quantitative pollination networks. To calculate the plants'  
164 relative floral abundance in their community, we aggregated floral counts for each species.  
165 We then calculated the mean visit potential of pollinator species  $i$  to plant species  $j$  as

$$o_{ij} = \frac{v_{ij} p_{ji}}{v_i p_j} )$$

166 ~~by~~ where  $v_{ij}$  is the observed number of visits by  $i$  to  $j$ ,  $p_{ji}$  is the number of pollen grains from  $j$   
167 attached to  $i$ ,  $v_i$  is the total number of visits performed by  $i$ , and  $p_j$  is the total number of  
168 grains carried by  $j$ . We log-transformed the number of shared pollinators, floral abundance,  
169 and visit potential before including them in the model.

170 Finally, functional originality is defined as the distance of a species from the community trait  
171 average—the centroid of functional space of the community (Laliberté and Legendre 2010,  
172 Coux et al. 2016). To include phenological variation, we treated floral abundance in each  
173 of the survey months (November to March) as a “trait” in ~~this~~ analysis. To account for the  
174 non-independence of floral counts and weight all traits equally, we assigned a weight of 1/5 to  
175 these abundances (one for each month). We scaled all traits before calculating the centroid  
176 of the functional space and calculated the species-specific functional coordinates using the R

is this  
richness  
of  
shared  
pollen?  
how do  
weights  
get  
used?

do we ever say  
or explain why  
we do this?

177 package FD 1.0-12 (Laliberté et al. 2014). Finally, we scaled all four factors to have a zero  
178 mean and unit~~ary~~ variance.

179 To estimate the coefficients, perform model selection, and quantify the associated uncertainty,  
180 we used a combination of multi-model inference and bootstrap resampling with 99 replicates.  
181 First, we performed model selection using ~~the~~ AICc and determined the likelihood of each  
182 candidate model (a particular combination of predictors) by calculating the median  $\Delta$ AICc  
183 (relative to the most likely model) for each bootstrap sample. As we wanted model coefficients  
184 from more likely candidate models to carry more weight in our results, we sampled the  
185 coefficients for our factors proportionally to the likelihood of their candidate model. Finally,  
186 we used these distributions of the model coefficients to estimate their mean impact on the  
187 pollination service (in terms of quantity and purity of conspecific pollen deposition).

## 188 Flexibility of plant strategies

189 Our second objective was to tease apart whether and how these factors that might affect  
190 pollen deposition might change across communities species are present. If community context  
191 plays a relatively small role, or species are inflexible in regards to these factors, we would  
192 expect plants of the same species to fill similar pollination niches across different communities.  
193 Alternatively, if the community plays a significant role and plant species are flexible, we  
194 should be able to observe differences in the realised niche a plant species occupies across  
195 communities. To test this, we first used a principal component analysis (PCA) of the four  
196 ecological factors (number of shared pollinators, floral abundance, visit potential, and trait  
197 originality). We scaled factors across the whole study to ensure that the PCA space does  
198 not change according to the species present in each community. We define a species' niche  
199 in a community as its coordinates <sup>this</sup> in PCA space. For each species that was present in two  
200 or more communities, we then calculated (i) the median distance between the strategies  
201 that the species uses in different communities and (ii) the area of the convex hull defined by

niche or  
strategy?  
are they the  
same?

202 these points in the first two principal components (only for species present in three or more  
203 communities). We then compared the magnitude of these two metrics to those obtained with  
204 99 Monte Carlo randomizations in which we replaced the strategy of the focal plant species  
205 by that of another randomly selected species in the dataset.

## 206 Results

### 207 Factors affecting quantity and purity of pollination service

208 We ~~then~~<sup>first</sup> examined the potential roles played in pollen deposition by four ecological factors  
209 (number of shared pollinators, abundance, mean visit potential, and functional originality).  
210 We found that our models of pollen deposition had high explanatory power (the coefficient of  
211 determination  $R^2$  ranged between 0.76 and 0.93) although a large portion of the explanatory  
212 power came from the random effects (Table S3). As determined by AICc, the random  
213 structure best supported by the data was the one that fit ~~an~~<sup>a separate</sup> intercept for each species in  
214 each community (as opposed to a common intercept for each species irrespective of the  
215 community to which they belong). This structure was best for both the models of conspecific  
216 and heterospecific pollen (Table S4).

217 Of the four factors we considered, we found that a plant's mean visit potential and relative  
218 floral abundance were the most important at predicting pollen deposition in plant stigmas  
219 (Fig. 1a). Surprisingly, the number of shared pollinators was comparatively unimportant,  
220 particularly for models of heterospecific pollen deposition, as it was only ever included in  
221 models with relatively large AICc values (Table S5).

222 [Figure 1 about here.]

223 We found that the relationship between each of the ecological factors and pollen deposition was  
224 similar for both conspecific and heterospecific pollen. That is, strategies that were associated

225 with an increase in conspecific pollen <sup>deposition</sup> were also associated with an increase in heterospecific  
226 pollen deposition. Specifically, the plants' mean visit potential had a positive effect on pollen  
227 deposition (Fig. 1b). However, the effect size was slightly larger for heterospecific than for  
228 conspecific pollen. This larger effect indicates that, although there is a positive association  
229 between visit potential and the quantity of pollen deposition, there is a negative relationship  
230 with its purity (Fig. 1c). In contrast, a plants' relative floral abundance negatively affected its  
231 deposition quantity, but the mean difference between the coefficients in the models indicates  
232 a positive association with purity (Fig. 1c). The third most important factor, functional  
233 originality, had a positive, although comparatively smaller, association with both the quantity  
234 and purity. Finally, the number of shared pollinators had negative and neutral associations  
235 with conspecific and heterospecific pollen, respectively, but these impacts were small when  
236 compared to the other factors. Although the ecological factors were positively correlated (Fig.  
237 S2), the collinearity between predictors did not qualitatively affect our findings (Fig. S3).

## 238 Flexibility of plant strategies

239 We used a PCA of the ecological factors–species matrix to investigate whether plants' <sup>vis</sup> "strategy"  
240 towards pollen deposition is similar across communities or whether they are flexible and  
241 therefore a reflection of the community context. The first two PCA components explained  
242 75% of the total variance (Fig. 2a). The first component was dominated by visit potential  
243 and relative abundance while the second component was dominated by the number of shared  
244 pollinators and the plant's functional originality. When we locate the species that were  
245 sampled in more than one community in the first two PCA components (Fig. 2b), we observe  
246 that the niches of any given species do not tend to be close to each other. Indeed, when we  
247 measured the median distance between the plants' coordinates, we found that it was only  
248 significantly smaller than that of randomisations for only two of the twelve species analysed  
249 (Fig. 2c).

## 251 Discussion

252 Our results suggest that community context plays a central role in determining the pollen  
 253 deposition dynamics and ultimately the net cost or benefit of sharing pollinators. First, we  
 254 found that multiple ecological factors can modulate the quality of the pollination service;  
 255 however, conspecific and heterospecific pollen deposition are tightly coupled and this creates a  
 256 clear trade-off between the quantity and purity of pollination (Thomson et al. 2019). Second,  
 257 we found that the way these factors shape pollen deposition for a species could be dramatically  
 258 different across communities. For instance, while in a particular community a plant species  
 259 could show high levels of pollinator sharing and relatively low trait differentiation, the same  
 260 species in another community can have relatively high trait differentiation and low levels  
 261 of pollinator sharing. Our findings highlight that trade-offs can at least partially explain  
 262 the coexistence of facilitative and competitive effects of animal-mediated pollination in the  
 263 pollination service both the short and the long term. —huh?

264 The trade-offs involved in attaining high-quality pollination service (and more broadly between  
 265 facilitation and competition) are likely to arise when plants simultaneously maximise the  
 266 deposition of conspecific pollen and minimise that of heterospecific pollen. In the short  
 267 term, being a specialist and sharing no pollinators might reduce competition (Muchhala et al.  
 268 2010) and hence be preferable. <sup>This may be both</sup> ~~not only~~ due to costs to male fitness (Morales and Traveset  
 269 2008, Muchhala and Thomson 2012), <sup>and</sup> ~~but~~ also ~~because~~ <sup>because</sup> as we show here, sharing pollinators  
 270 reduces both the quantity and purity of the conspecific pollen deposited. However, over long  
 271 periods of time, there could be a risk associated with a specialist plant having few pollinators  
 272 (Ricketts 2004). To ensure long-term survival, it is thus likely that plants also need to balance  
 273 this risk with the costs of sharing pollinators (Aizen et al. 2012). One possible solution is

274 to share pollinators *and* have original traits—as we show that trait originality is generally  
 275 beneficial to pollen deposition and it is commonly thought that species that are further from  
 276 others in trait space benefit from reduced competition. Yet, there are two possible caveats to  
 277 this strategy that highlight the interrelatedness of the ecological factors. First, in a mutualism  
 278 context, it is also possible that trait originality could come at the cost of being less ‘apparent’  
 279 to pollinators (Reverté et al. 2016). Second, the negative relationship between originality and  
 280 generalism (Carvalho et al. 2014) has been shown to depend on plant abundance (Coux et  
 281 al. 2016), with generalist species being able ~~to~~ to have original traits only when they are *a lot*  
 282 abundant enough to provide a valuable reward to make visiting worthwhile to pollinators.

283 Visit potential (high pollen and visits) and floral abundance, which were the most important  
 284 predictors of pollen deposition here, introduced an even more explicit trade-off between  
 285 gaining conspecific pollen and avoiding heterospecific pollen. Receiving high visitation  
 286 increases conspecific pollen deposition but increases heterospecific pollen deposition to a  
 287 greater extent—even when the visitors are likely to carry a high proportion of conspecific  
 288 pollen (Fang and Huang 2016). Contrastingly, being abundant reduces the amount of  
 289 conspecific pollen deposited and simultaneously reduces heterospecific pollen at a faster rate.

290 Our results corroborate the importance that two-species studies have ascribed to visitation  
 291 and abundance (Feldman et al. 2004, Muñoz and Cavieres 2008, Morales and Traveset 2008),  
 292 but they also suggest that (because visitation, pollen production and abundance are usually  
 293 correlated; Sargent and Otto 2006) balancing the pros and cons of sharing pollinators at the  
 294 community level is not trivial and might even be partially responsible for the diversity of  
 295 plant-pollinator communities (Benadi and Pauw 2018). — I don't get this.

296 We observed, as expected, that the effects of pollen deposition can vary widely among species.  
 297 For instance, ~~while the~~ the fitness of some plant species can be hurt even by low amounts of  
 298 heterospecific pollen, ~~for others~~ *while the* fitness *of others* can instead be limited by the amount of conspecific  
 299 pollen (Campbell and Motten 1985, Arceo-Gómez et al. 2019). Alternatively, plant species

this phrasing could cause confusion based on the term as it appears in invasion literature

300 can also differ substantially in the extent to which self- vs. outcross-pollen differ in their  
301 value for fertilization. The difference can be particularly relevant for species that are not  
302 self-fertile or those in which self-fertilization is rarely effective due to a temporary separation  
303 in the maturation of the sexes (dichogamy).

304 Importantly, we show here that the balances between costs and benefits are determined not  
305 only by species identity but also by the community to which plants belong. Specifically, most  
306 plant species appear to be flexible enough to adopt markedly different niches in different  
307 communities. From an evolutionary perspective, our results suggest that selection for a  
308 particular strategy might say something about the community in which a species has typically  
309 inhabited during its evolutionary history. Furthermore, from a more applied perspective,  
310 flowering plants are sometimes introduced to attract pollinators on other nearby plants. On  
311 the one hand, our results suggest that introduced plants that increase the relative originality  
312 of natives (e.g. through distinct phenology) might have positive effects (Gibson et al. 2012).  
313 On the other, because different niches can lead to different outcomes across communities,  
314 our results also highlight the difficulties involved in predicting whether the introduced plant  
315 species will facilitate or compete with neighbours (Bartomeus et al. 2008). Other factors that  
316 we were unable to measure (e.g. pollinator behaviour and densities or the spatial context)  
317 have also been shown to play a role in the outcome of animal-mediated pollination (Cariveau  
318 and Norton 2009, Flanagan et al. 2011, Ye et al. 2014, Thomson et al. 2019). Nevertheless,  
319 our results indicate that the strategies a plant might use to successfully minimise competition  
320 for pollination (or maximise facilitation) must be determined relative to other species in the  
321 community, rather than an absolute property of the species itself.

322 Overall, using empirical data on pollen deposition, we show ~~that~~ at the community level *that*  
323 sharing pollinators has a smaller effect on pollen deposition than what we expected based on  
324 experimental studies with a handful species. Other factors that underpin community dynamics  
325 (abundance, traits, visitation) also influence patterns of pollination quantity and purity. The

326 interrelatedness of these factors, and the flexibility of species to position themselves <sup>across</sup> ~~within~~  
327 ~~these factors~~ <sup>them,</sup> means that their contributions to the quality of the pollination service ~~should not~~  
328 ~~and~~ cannot be understood in isolation. All <sup>of the</sup> factors we analysed involve substantial trade-offs  
329 in pollen deposition in the short and likely also in the long ~~my~~ term. These trade-offs emphasise  
330 <sup>inherently</sup> the competitive nature of pollination. However, many of the widely used theoretical models  
331 of plant-pollinator communities do not account for the adverse effects of sharing pollinators  
332 (but see Rohr et al. 2014 and similar). We <sup>therefore</sup> propose that achieving a better understanding of  
333 species coexistence and how pollination supports plant biodiversity will require seeing them  
334 as both mutualistic and competitive communities (Johnson and Bronstein 2019).

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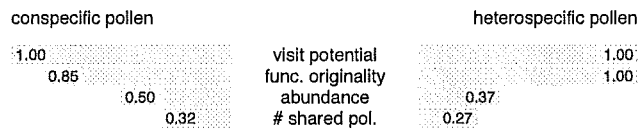
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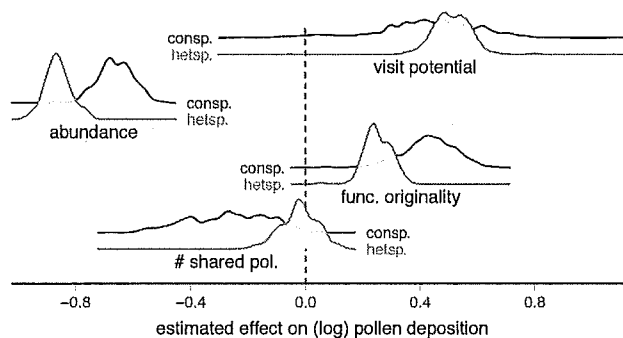
## 467 List of Figures

468	1	Effect of ecological factors on the pollination service. (a) The plant's visit	
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**(a) relative variable importance**



**(b) distribution of effects**  
based on 100 bootstrap replicates



**(c) mean effect on pollination service**

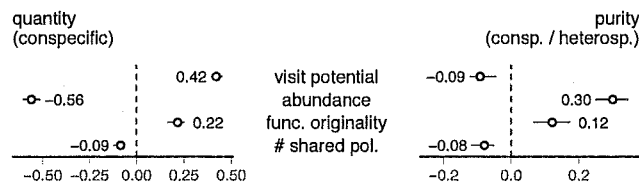


Figure 1: Effect of ecological factors on the pollination service. (a) The plant's visit potential and relative floral abundance are the most important factors determining the deposition of conspecific and heterospecific pollen. Meanwhile, the number of shared pollinators was generally less important. The graph shows the relative importance calculated as the sum of the Akaike weights of the candidate models that included the selected factor. (b) The association between ecological factors and heterospecific pollen tended to align with their association with conspecific pollen. Visit potential and functional originality had a positive association with pollen deposition while floral abundance and the number of shared pollinators had a negative association. The plot shows the distribution of the effects (across 99 bootstrap replicates) of the four ecological factors for conspecific and heterospecific pollen. (c) The end result of these associations is that only the plants' functional originality has a positive impact on both the quantity and purity of conspecific pollen deposition (relative to heterospecific pollen). The plot shows the model averaged mean effect ( $\pm$  SE of 99 bootstrap replicates).

(black line)

(green line)

can/should you  
make one  
dashed?

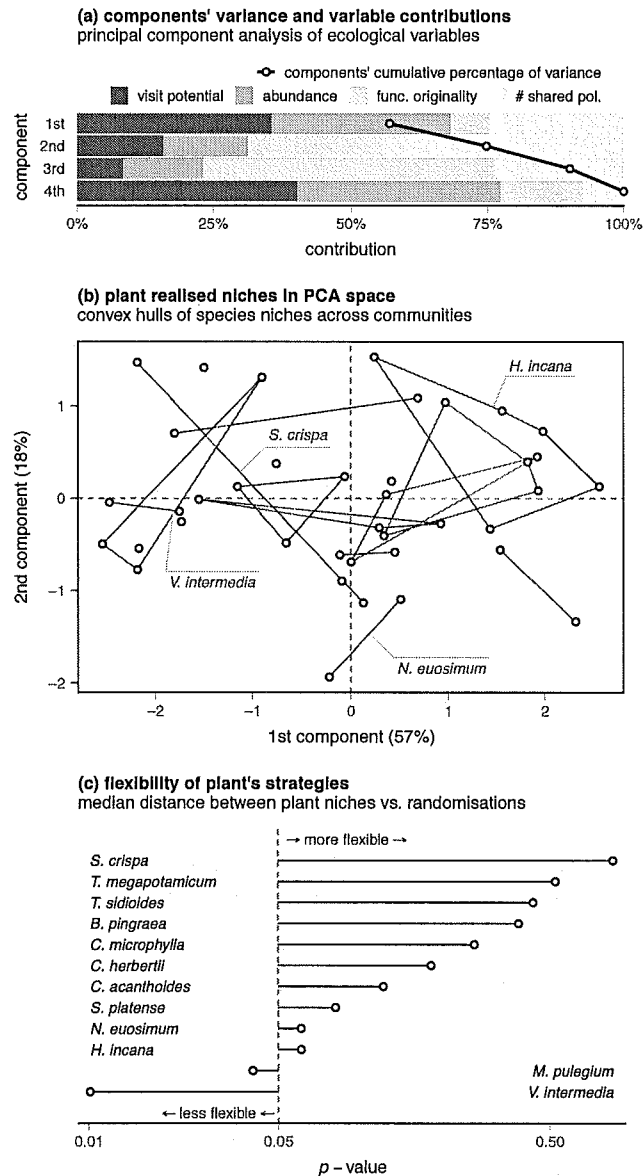


Figure 2: The flexibility of plant strategies. (a) The two first components explain a large proportion of the total variance. (b) When plants that were sampled in more than one community are plotted in terms of these two components, we observe that their points, which represent the strategy (the particular combination of ecological factors) of that species in its community, do not seem to be grouped by plant species. (c) This was confirmed using Monte Carlo randomizations of the median distance between strategies of a plant species. Only two of the examined species had strategies that were less flexible than would be expected at random.

Community context determines competition  
vs. facilitation trade-offs in pollination systems

Supplementary information

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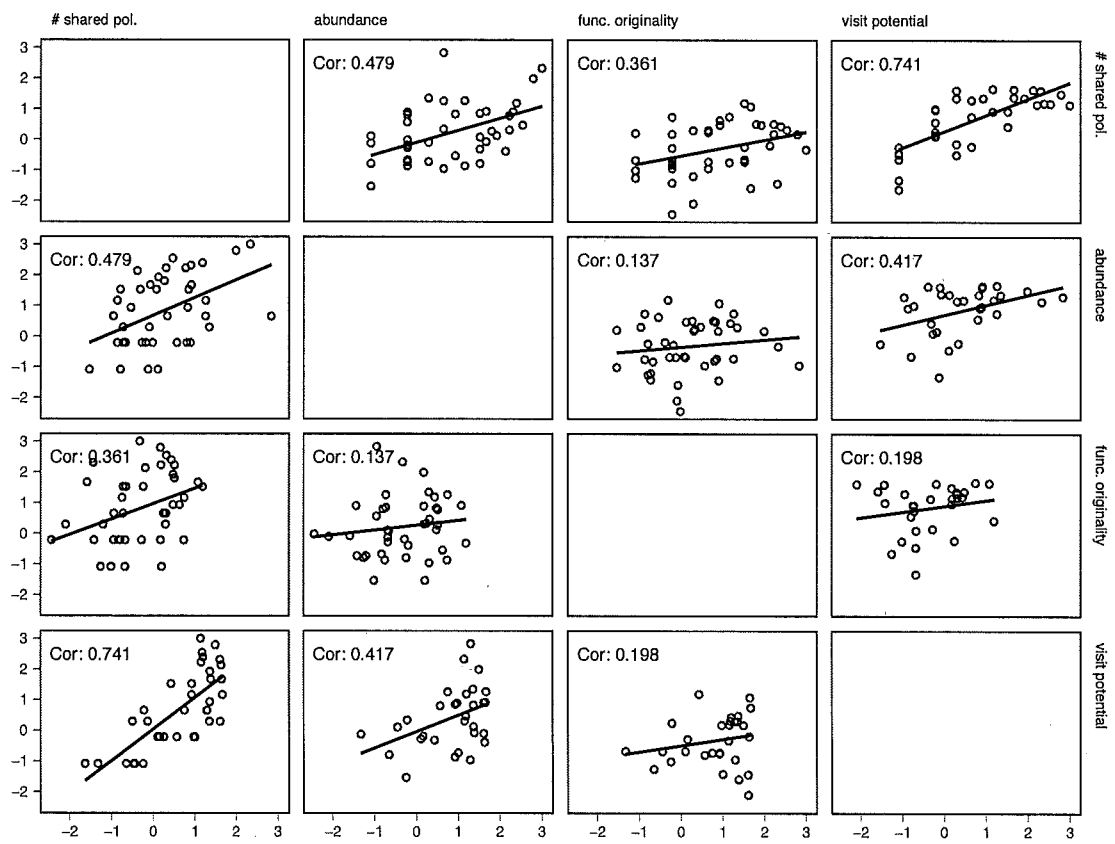


Figure S2: Correlation between the explanatory variables included in the statistical models.

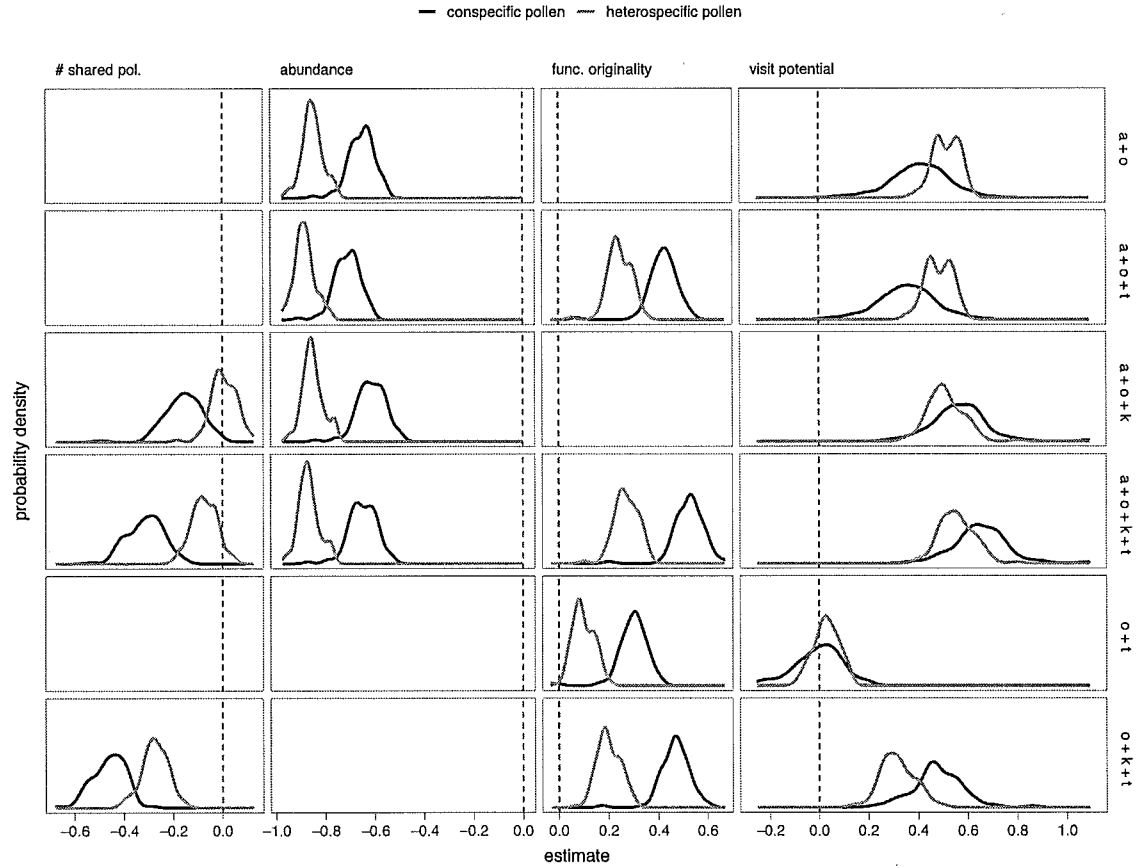


Figure S3: Distribution of effect estimates for models of conspecific and heterospecific pollen density gain. Model formulas have been abbreviated:  $a$  for abundance,  $k$  for the number of shared pollinators,  $o$  for the visit potential, and  $t$  for functional originality. Only candidate formulas with a  $\Delta AICc < 4$  for either conspecific or heterospecific pollen are shown. Model candidates are arranged in decreasing order of support. Although relative abundance, the number of shared pollinators, and the visit potential were all positively correlated, the effect each had on conspecific pollen was similar among models that included all or just some of these three explanatory variables. One exception was visit potential, which exhibits a positive association with the relative amount of conspecific pollen under some variable combinations. Nevertheless, these differences were observed only in model specifications with relatively low AICc support.