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Floristic composition of Isla de las Gaviotas, Río de la Plata estuary, Uruguay

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Abstract: Isla de las Gaviotas is an island located in Río de la Plata estuary, Uruguay. The aim of this study is to determine and analyze plant species composition on this island and to identify vegetation zonation patterns. An angiosperm species list was generated using a qualitative sampling technique. We registered a total of 27 species, distributed among 18 families. According to species distribution patterns on the island, we propose four vegetation zones: North, Central, Southeast and West. Exotic species comprised 52% of the total number of species, reflecting a history of disturbance in the area. Nonetheless, this site also has a remarkable number of native species, in particular *Heliotropium curassavicum*, which is listed among Uruguayan species of conservation concern. Given that the loss of coastal plant species is a current problem, the proportion of native halophyte species recorded (37%) indicated the island's importance as a relict of Uruguayan coastal vegetation.

Introduction

The Río de la Plata estuary possesses outstanding biodiversity and is considered one of the world's largest and most dynamic aquatic systems because of its length, breadth and flow rate (average discharge is 22,000 $m^3 s^{-1}$) (Framiñan and Brown 1996; Vizziano *et al*. 2002). The Uruguayan coast extends approximately 450 km along the Río de la Plata estuary (MTOP-UNDP-UNESCO 1979). The coastline of this estuary consists of a series of rocky points, sandy beaches, coastal cliffs, dunes, littoral lagoons and islands (Chebataroff 1969). In association with different geomorphological formations, several vegetation types are distributed, including bunchgrasses, rush vegetation and coastal grasslands (Fagúndez and Lezama 2005). Since the late nineteenth century, the Río de la Plata coast has been highly modified by increased tourism, the introduction of exotic species and urbanization (Delfino and Masciadri 2005; Alonso-Paz and Bassagoda 2006; Delfino *et al*. 2011). These activities have fragmented the original vegetation into reduced patches along the coastline.

Within the Río de la Plata estuary there are many islands of different geological origin: some are sedimentary but most are crystalline (Chebataroff 1969). The scarcity of scientific studies on these islands has severely limited our understanding of the diversity and distribution of their vegetation (Vaz Ferreira 1950). Isla de las Gaviotas is one of the smallest coastal islands within the estuary and has been heavily disturbed by several human activities. For many years, the island has had free public access with a high flux of visitors. These activities, combined with the proximity of the island to Montevideo and the influence of river currents, have probably led to the accumulation of waste on the island. As a result, a restoration process was initiated, which included the elimination of rubbish and certain pests and the planting of exotic woody species. Since 1992, the protection of the island has been managed by a non-governmental organization (Uruguay PL 1992) and access to the island is restricted by law (Uruguay PL 1992). A few surveys of flora and fauna have been conducted but none have been published (C. Brussa, pers. comm.). Currently, the island is an important nesting, feeding and resting area for seabirds and shorebirds (Lenzi *et al*. unpubl. data).

There is a lack of baseline information regarding species composition and distribution of vegetation of coastal islands in the Río de la Plata estuary. Due to the importance of Isla de las Gaviotas as a refuge for flora and fauna, descriptive studies of its flora may contribute to designing future management plans. As such, the aim of this study is to determine and analyze plant species composition on Isla de las Gaviotas, and identify zonation patterns of the vegetation. This study will allow further evaluation of the island's current conservation status and contribute to the general knowledge of coastal vegetation in Montevideo.

Materials and Methods

Study site

Isla de las Gaviotas (34°54'10" S, 56°06'16" W) is located in the Río de la Plata estuary, approximately 400 m off the coast of Uruguay, opposite Montevideo (Figure 1). The island has a total surface area of approximately 17,000 m^2, including the main island and flooded areas (estimated from Google Earth, scale 1:25000). The surface area of the island is about 11,000 m^2, which corresponds to the zone with vegetation cover, as the rest are largely rocky outcroppings. The island is of crystalline origin, with a predominance of sandy substrate in the north zone and rocky outcrops in the southern zone. In the Río de la Plata estuary, salinity varies from 1 to 32 ppt during the

year (Fossati and Piedra-Cueva 2003). A turbidity front is approximately located off the coast of Montevideo, the position of which varies with the combined effects of several forces, such as total discharge from the Uruguay and Paraná Rivers into the Río de la Plata estuary, the balance between onshore and offshore winds, and tidal influences (Framiñan and Brown 1996; Trimble *et al*. 2010).

According to the Köppen–Geiger climate classification system, the study area falls within the *Cfa* climate category, characterized by a humid subtropical climate with hot, humid summers and mild to cool winters (McKnight and Hess 2000). The mean temperature of Montevideo is 16.5°C and total annual precipitation is 1198 mm (Carrasco meteorological station, DNM 2012).

Data collection

Fieldwork on Isla de las Gaviotas was carried out during two field trips in November and December of 2011. During our surveys, we compiled a complete species list of angiosperms. Prior to fieldwork, seven sampling points on the main island were established at a minimum distance of 30 m and geo-referenced using satellite images (Figure 1). Sampling quadrants (30 x 30 m), centered on each sampling point, were used to survey floristic composition. Vegetation between quadrants was also observed for the presence of species not recorded within the established quadrants. Some species were identified in the field while others were determined using botanical keys and regional flora (Legrand 1943; Lombardo 1982; 1983; 1984) as well as consultation with specialists and the herbarium collection at the "Profesor Atilio Lombardo" Botanical Garden and Museum (MVJB, Montevideo, Uruguay).

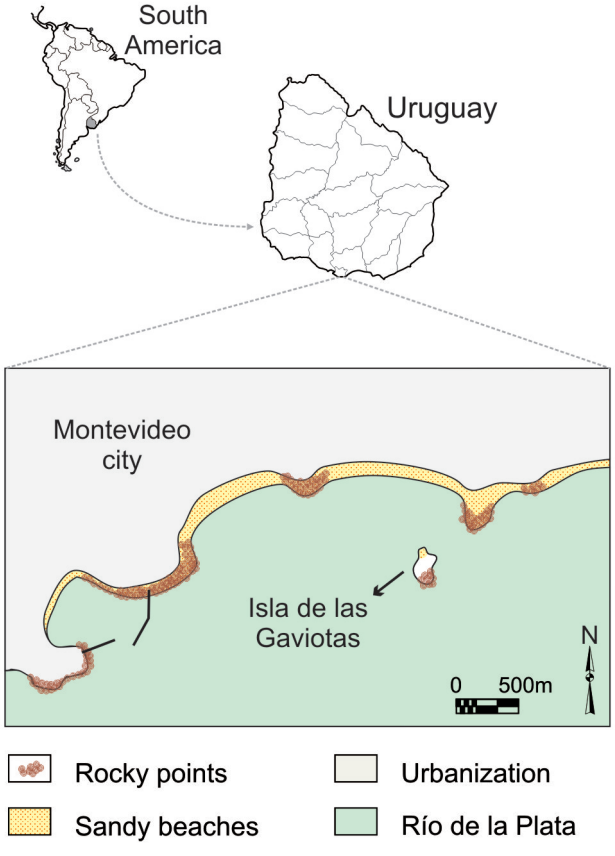

Figure 1. Location of Isla de las Gaviotas, Montevideo coast, Uruguay.

Species names were assigned following APG III (2009), and nomenclature and author citations for all species were conferred in the Tropicos database (tropicos.org. Missouri Botanical Garden 2012). Species habit (herb, tree, shrub, climber) and status (native, exotic, cosmopolitan) was assigned according to Zuloaga *et al.* (2008). All native species were collected and deposited with a voucher number in the MVJB herbarium collection.

Results and Discussion

A total of 27 species were registered on Isla de las Gaviotas, belonging to 27 genera and 18 families (Table 1). No new species were observed in the space among quadrants. Most of the species were herbaceous (81.5%). Amaranthaceae and Poaceae were the most species-rich families, with four species in each one. Nonetheless, most families were represented by only one species. The absence of Asteraceae and Cyperaceae was unexpected, given that these are very common families on the Uruguayan coast.

Halophytes comprised 41% of all species identified. These plants have various xeromorphic traits (*e.g*., high cellular osmotic pressure, succulence, leaf absence, curled leaf laminae) associated with tolerance to high salt concentrations (Chebataroff 1952; Legrand 1959). Due to the adaptive traits that permit salt tolerance or avoidance, many of these species are distributed in saline environments around the world (Chebataroff 1952). The percentage of halophyte species recorded included cosmopolitan, native and exotic species present along the Uruguayan coast (Lombardo 1982; 1983; 1984).

Despite the important presence of native plant species, 52% of species were exotic, reflecting the history of disturbance of the site. Herbs comprised 71% (10 species) of exotic species, while woody species comprised 29%.

Zonation patterns

Based on species composition and physiognomy of vegetation at each sampling quadrant, we proposed a zonation scheme for the entire study site. Four vegetation zones were identified: North, Central, Southeast and West (Figures 2 and 3). The North Zone was mainly characterized by sandy sediments and low plant species cover. Among the species found exclusively in this zone, *Rumex cuneifolius* was the only native halophyte (Table 1; Figure 4). In addition, *Atriplex prostrata* was a widespread species. This species is a facultative halophyte, which exhibits its most extensive branching and largest total biomass in conditions of low or no salinity (Wang *et al.* 1997). On the other hand, some edible species such as *Beta vulgaris* and *Raphanus sativus* were found, which usually grow spontaneously in disturbed areas (Lombardo 1982). For these species, seeds could have been planted by people in the past or dispersed by birds that inhabit the island (*e.g*., Kelp Gull *Larus dominianus*, Neotropic Cormorant *Phalacrocorax olivaceus*, Egrets *Egretta thula* and Cattle Egret *Bubulcus ibis*, as well as various passerine birds).

The Central Zone was the most affected by human activity and was largely composed of introduced species (64%) (Table 1; Figure 4). We registered two invasive grass species for Uruguay, *Arundo donax* and *Cynodon dactylon*, which outcompete native species and have largely negative consequences for coastal ecosystems

(Brugnoli *et al.* 2010; Masciadri *et al*. 2010). In this zone, exotic tree and shrub species were also present, such as *Phoenix canariensis*, *Myoporum laetum*, *Ricinus communis* and *Tamarix ramosissima*. Usually, these non-American woody species are intentionally planted for ornamental purposes or, in the case of *T. ramosissima*, to stabilize dunes in coastal zones (De Marco *et al*. 2011). Nonetheless, they also grow spontaneously in disturbed areas (De Marco *et al*. 2011). Currently, these four species provide refuge and nesting sites for birds such as Cattle Egret (*Bubulcus ibis*), Snowy Egret (*Egretta thula*), Rufous-collared Sparrow (*Zonotrichia capensis*), Cattle Tyrant (*Machetornis rixosus*) and Harris's Hawk (*Parabuteo unicinctus*) (Lenzi *et al.* unpubl. data). Certainly, this is an important consideration for future conservation and management decisions for the island.

The Southeast Zone was mainly rocky and included a large, non-vegetated flooded area (Figures 2 and 3). This zone had the highest proportion of native and halophyte species on the island (77% for both groups). There were large areas characterized by an association of *Paspalum vaginatum*, *Juncus acutus* and *Spartina longispica* (Table 1).

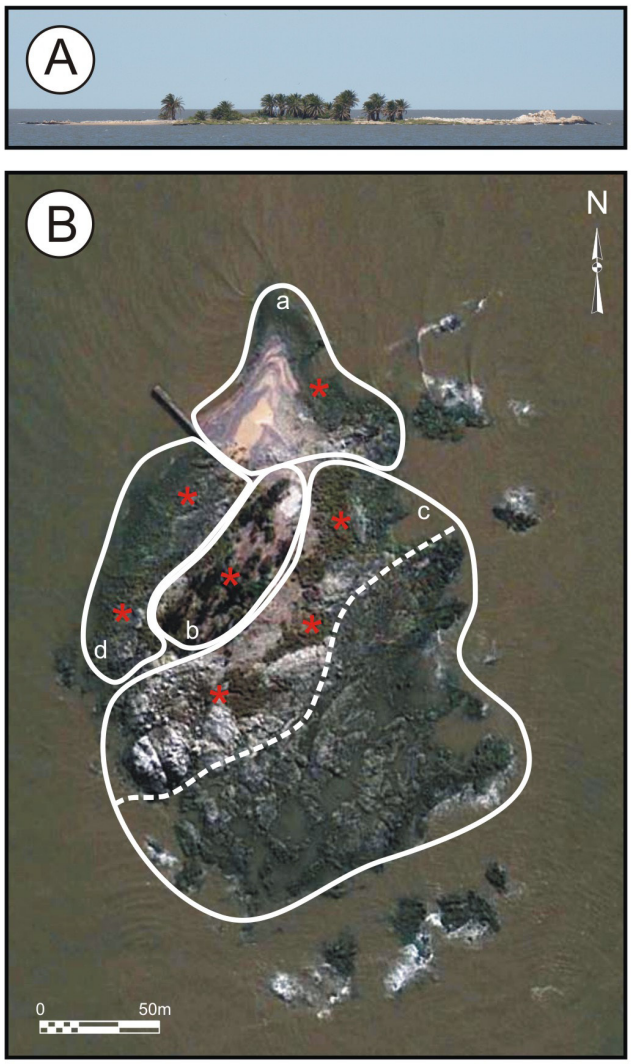

Figure 2. A. Isla de las Gaviotas; B. Zonation of the island: a) North zone; b) Central zone; c) Southeast zone; and d) West zone. The dashed line represents the limit between the rocky outcrops and the Southeast vegetated zone. Red asterisks represent sampling points. Picture date 18/05/2011, Google Earth.

In halophyte-dominated floodplains these species usually establish mono-specific stands or communities with low species richness (Rossengurt 1944). In this zone, other halophyte species such as *Limonium brasiliense*, *Polygonum brasiliense*, *Sarcocornia perennis* and *Spergularia marina* were also present (Table 1) (Rossengurt 1944; Chebataroff 1950; 1952; Legrand 1959). The high proportion of halophyte species is probably associated with the particular environmental characteristics that distinguish this zone, including isolated puddles in rocky areas with high salinity (Legrand 1959) and high exposure to strong winds from the southeast.

The West Zone had a mixed sandy and rocky substrate with high vegetation cover and a relatively similar proportion of native and exotic halophytic species (Figures 3 and 4). *Conium maculatum* was exclusive to this zone (Table 1), and there was extensive coverage of *S. longispica*.

Some angiosperm species of Isla de las Gaviotas are ilustrated in Figures 5 and 6. Among the species identified on the island, we found one species included in the Uruguayan species list for conservation concern, *Heliotropium curassavicum* (Soutullo *et al*. 2009), observed in the North, Central and Southeast zones (Table 1, Figure 5L). Although *H. curassavicum* used to be a common species along the Río de la Plata coast (Lombardo 1982), only a few individuals were known to persist in Montevideo by the 1980's. As a result, the species is listed as a priority species for conservation due to its restricted distribution on sandy soils in Uruguay (Soutullo *et al*. 2009), although it also occurs in Argentina, Brazil and Paraguay (Lombardo 1982).

Final considerations

This study constitutes the first angiosperm collection for Isla de las Gaviotas. It also makes an important contribution to the botanical collections of vegetation in Uruguay, providing data on species with poor botanical records (*e.g*., *P. brasiliense* and *A. prostrata*) and expanding the knowledge base regarding current species distribution patterns. Furthermore, this research makes an important contribution to the knowledge of the flora of the Río de la Plata islands and provides baseline information on the vegetation of Isla de las Gaviotas. In this study, we identified four vegetation zones within the island, distinguished by differences in abiotic characteristics and species composition over a very small area.

Despite the high occurrence of exotic species, which may reflect past human activity, the island still has a substantial number of native species, including *H. curassavicum*, which is designated as of conservation priority. Given the increased loss of native coastal species along the Río de la Plata coastline, the native and halophyte species recorded here suggest the island is a relict of the original vegetation that inhabited the coast of Montevideo. Further field studies on islands within the Río de la Plata estuary are necessary to enhance the understanding of variation in species composition in the region. Additionally, the availability of current species lists provides updated knowledge on species composition to inform future management guidelines regarding the protection of the island.

Figure 3. Illustrations of each zone: a) North zone; b) Central zone; c) Southeast zone; d) West zone.

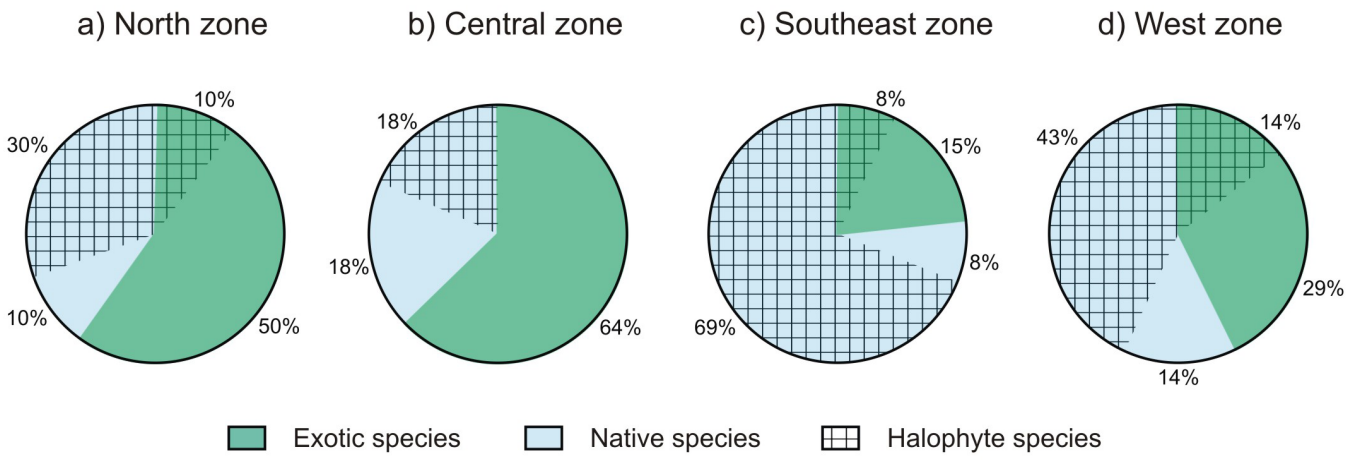

Figure 4. Exotic, native and halophyte species composition of Isla de las Gaviotas for each zone.

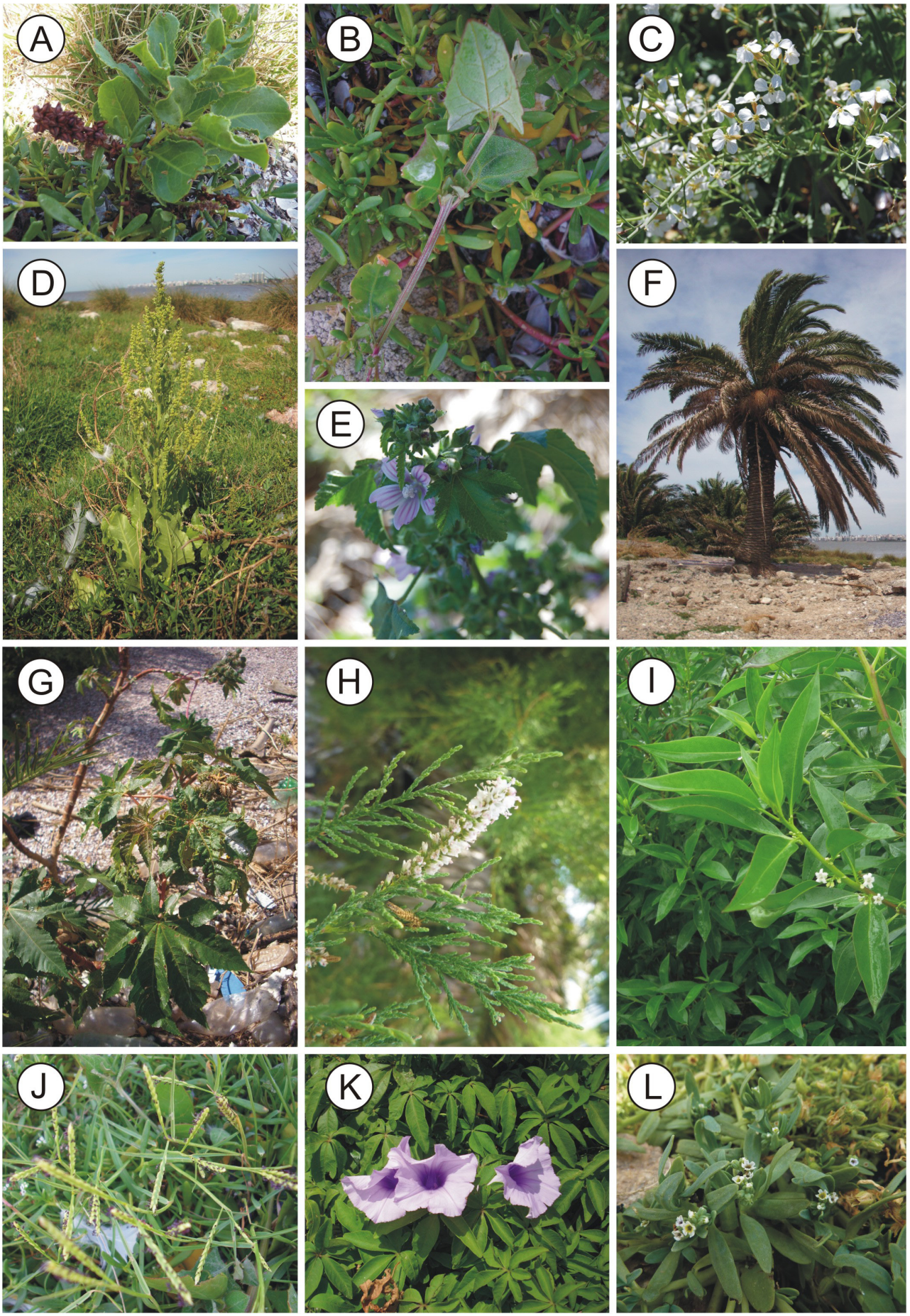

Figure 5. Some angiosperm species of Isla de las Gaviotas, Uruguay. A. *Rumex cuneifolius* (Polygonaceae); B. *Atriplex prostrata* (Amaranthaceae); C. *Raphanus sativus* (Brassicaceae); D. *Beta vulgaris* (Amaranthaceae); E. *Malva parviflora* (Malvaceae) F. *Phoenix canariensis* (Arecaceae); G. *Ricinus communis* (Euphorbiaceae); H. *Tamarix ramosissima* (Tamaricaceae); I. *Myoporum laetum* (Scrophulariaceae); J. *Paspalum vaginatum* (Poaceae); K. *Ipomoea cairica* (Convolvulaceae); L. *Heliotropium curassavicum* (Boraginaceae).

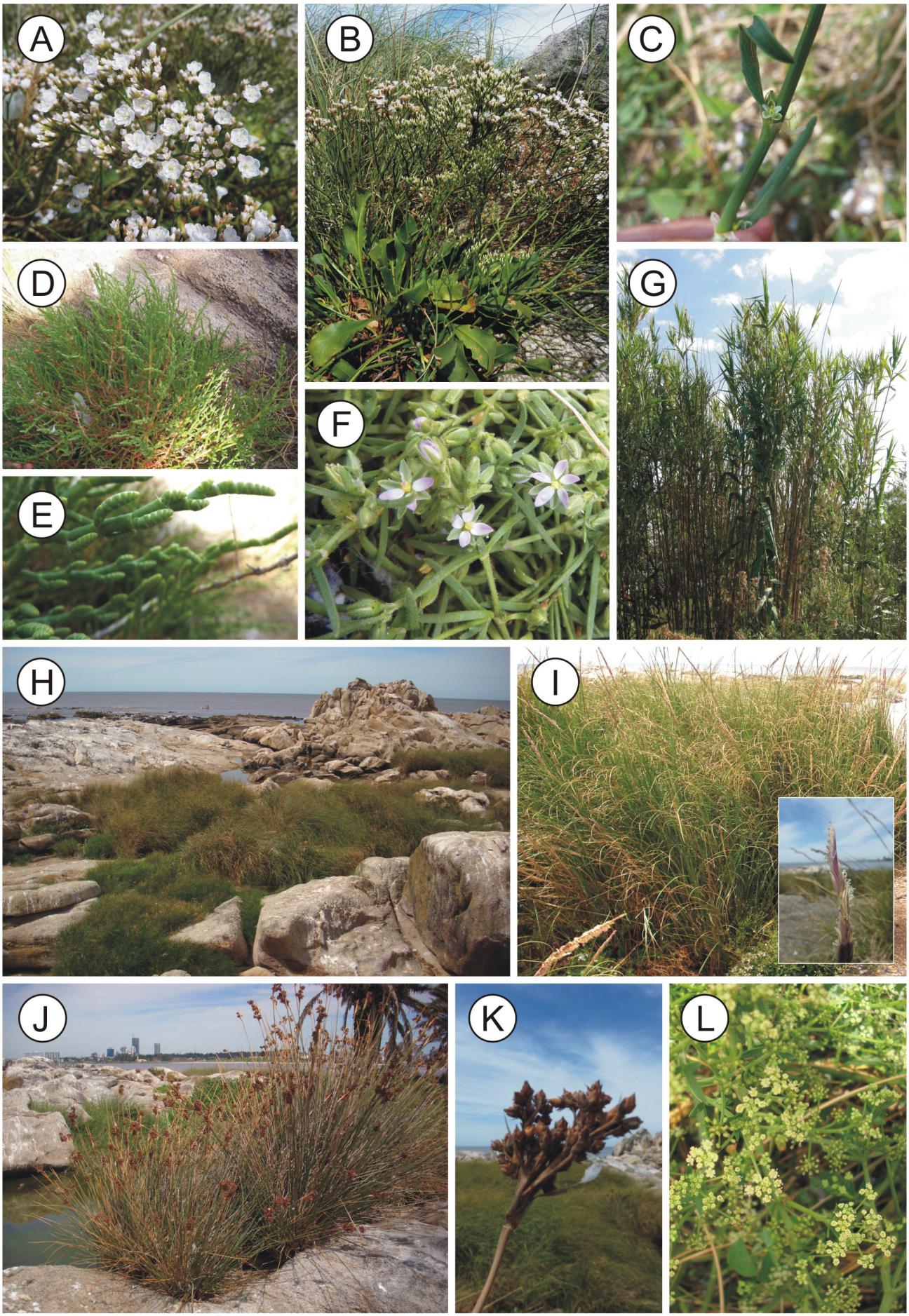

Figure 6. Some angiosperm species of Isla de las Gaviotas, Uruguay. A-B. *Limonium brasiliense* (Plumbaginaceae); C. *Polygonum brasiliense* (Polygonaceae); D-E. *Sarcocornia perennis* (Amaranthaceae); F. *Spergularia marina* (Caryophyllaceae); G. *Arundo donax* (Poaceae); H. *Paspalum vaginatum* and *Spartina longispica* (Poaceae); I. *Spartina longispica* (Poaceae); J-K. *Juncus acutus* (Juncaceae); L. *Conium maculatum* (Apiaceae).

Table 1. List of angiosperm species recorded on the Isla de las Gaviotas according to Angiosperm Phylogeny Group III Classification (2009). Species habit: H – Herb, T – Tree, S – Shrub, C – Climber. Species status (N – Native, E – Exotic, Co – Cosmopolitan).

FAMILIES / SPECIES	HABIT	STATUS	HALOPHYTE	NORTH	CENTRAL	SOUTHEAST	WEST	VOUCHER NUMBER
Aizoaceae								
Sesuvium portulacastrum (L.) L.	H	Co	x	x	x	x		MVJB N°27964
Amaranthaceae								
Alternanthera philoxeroides (Mart.) Griseb.	H	N			x			MVJB N°27960
Atriplex prostrata Boucher ex DC.	H	Co	x	x		x	x	MVJB N°27968
Beta vulgaris L.	H	E		x	x			MVJB Nº27979
Sarcocornia perennis (Mill.) A.J. Scott	H	N	x		x	x		MVJB N°27966
Apiaceae								
Conium maculatum L.	H	E					x	MVJB N°27977
Arecaceae								
Phoenix canariensis Chabaud	T	E			x			-
Boraginaceae								
Heliotropium curassavicum L.	H	N	x	x		x	x	MVJB N°27961
Brassicaceae								
Raphanus sativus L.	H	E		x				MVJB N°27976
Rapistrum rugosum (L.) All.	H	E		x				MVJB N°27971
Caryophyllaceae								
Spergularia marina (L) Griseb.	H	Co	x			x	x	MVJB N°27962
Convolvulaceae								
Ipomoea cairica (L.) Sweet	C	Co			x			-
Euphorbiaceae								
Ricinus communis L.	S	E			x			-
Fabaceae								
Melilotus indicus (L.) All.	H	E		x				MVJB N°27978
Juncaceae								
Juncus acutus L.	H	N	x			x		MVJB N°27957
Malvaceae								
Malva parviflora L.	H	E				x		MVJB N°27974
Plumbaginaceae								
Limonium brasiliense (Boiss.) Kuntze	H	N	x			x		MVJB N°27959
Poaceae								
Arundo donax L.	H	E			x			-
Cynodon dactylon (L.) Pers.	H	E		x	x		x	-
Paspalum vaginatum Sw.	H	N	x			x		MVJB N°28049
Spartina longispica Hauman and Parodi ex St.-Yves	H	N		x		x	x	MVJB N°27982
Polygonaceae								
Polygonum brasiliense K. Koch	H	N	x			x		MVJB N°27965
Rumex cuneifolius Campd.	H	N	x	x				MVJB N°27970
Portulacaceae								
Portulaca oleracea L.	H	E				x		MVJB N°27958
Scrophulariaceae								
Myoporum laetum G. Forst.	T	E			x			-
Tamaricaceae								
Tamarix ramosissima Ledeb.	S	E			x			-

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